Space/Aeronautics

THE MAGAZINE OF AEROSPACE TECHNOLOGIES

SEPTEMBER 1961

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Equipment Design for HEAT TRANSFER

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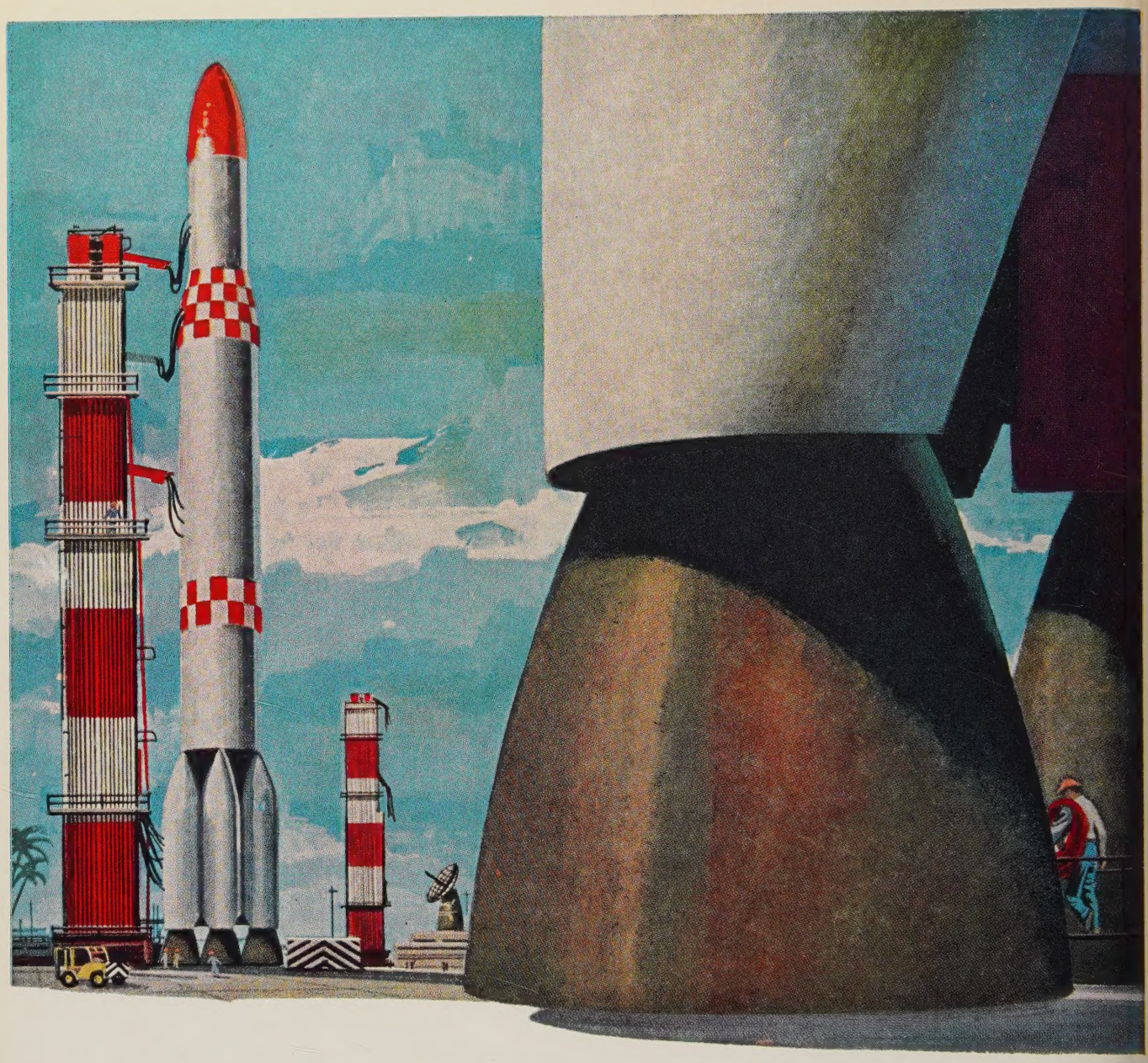

THE BIGGEST PLASTIC ROCKET NOZZLES ARE FROM HITCO

Coming... rockets that will dwarf—in size and thrust—every preceding launching. The plastic components that will gird them for flight will be manufactured to standards only recently considered impractical.

The Dumont Division of HITCO has advanced the art of molded plastics to this capability in the brief period of four years. Now, under HITCO, a combined team of engineers and technicians has made technological breakthroughs in both insulative and ablative plastics. New tooling techniques have been developed; the Dumont hydroclave can put pressure of up to 6500 psi uniformly on the surface of a reinforced plastic part. Dumont and HITCO are currently molding rocket engine components at pressures up to 30,000 psi.

Though giant rockets are still in the planning stage, the *giant plastic capabilities are here today*. HITCO is ready *now* to fit the biggest rockets with the biggest plastic nozzles.

HITCO-developed ablative materials and fabrication techniques are also providing Atlas and Titan nose cone heat shields. These materials enabled the first ICBM nose cone recovery.

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Space/Aeronautics

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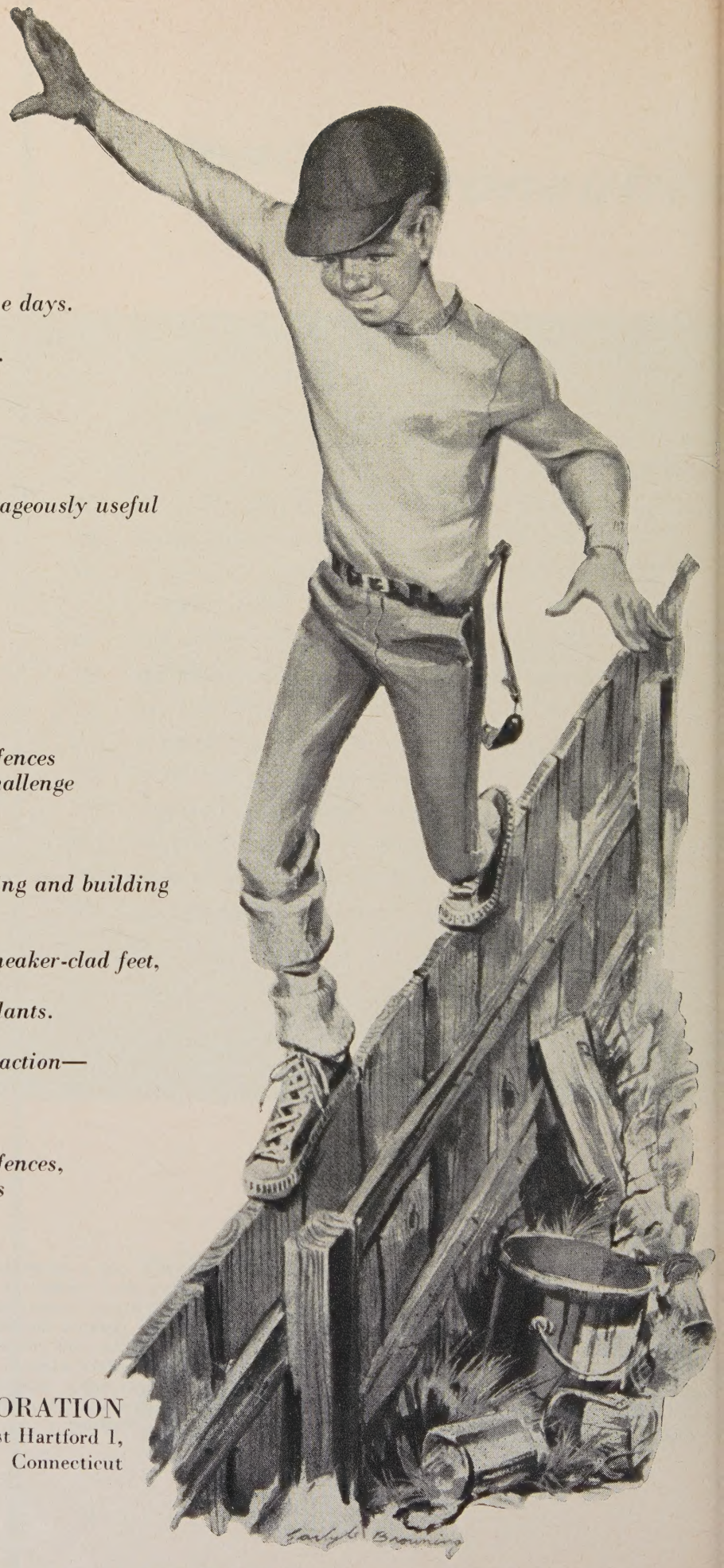
COMING

November will bring a bonus to S/A readers: a separately bound, full-size special report on ground support technology, in addition to the regular issue. The report will be in three parts. The first section is an alphabetized, quick-reference index to the GSE capabilities of every major company in the field, with the specialties of each graphically highlighted. Section two gives a listing-in-depth of each company's GSE experience, in the form of recent contracts, together with a rundown on areas of capability and special skills, and a list of GSE literature available from each firm. The third section is a detailed engineering analysis of GSE design trends, problems, plans and requirements. The areas covered include automatic checkout; range instrumentation and ground data processing; booster handling and nuclear support; launch monitoring and control; and in-flight space support. Military criticisms of present GSE designs and the needs of each service for the future are also reviewed.

Born to it!



Board fences are hard to find these days.
And it's a pity, too.
Boys are born to balance on them.

Take the little guy over yonder.

Like all boys,
he has a highly sophisticated
system of control—one that's outrageously useful
on a board fence.
He has sensing devices
to signal just the right muscles,
and muscle mechanisms
to take just the right action—
even if it amounts only to
wiggling his toes
in his sneakers.

A lot of former walkers of board fences
are today looking ahead to new challenge
out in a vast region
called space.

Some are here with us . . . designing and building
control systems for space vehicles.

Instead of imparting motion to sneaker-clad feet,
we've got to move control surfaces,
nozzles, even entire rocket powerplants.
And instead of wiggling toes,
we've got to steer space craft by reaction—
developing small thrust pulses
at their sides.

Just as boys have an affinity for fences,
we feel we are born to assignments
like these.
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For assistance with your control and control system problems, contact Mr. L. G. Burns, Vice President

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abstracts

Technical Management

Do we still need manned bombers?

Analysis of pros and cons of the manned bomber and B-70 controversy based on Pentagon interviews and congressional testimony.

by Randolph Hawthorne, Editor

space/aeronautics 36/3 (Sep. '61) p. 52

Test Engineering, Materials

Arc-imaging furnace tests materials in high thermal flux

Reports on an arc-imaging furnace that delivers thermal fluxes as high as 600 cal/ cm^2/sec to a specimen in a very pure form. Describes uses of this thermal flux facility in various types of materials research.

by Octave Romaine, Associate Editor

space/aeronautics 36/3 (Sep. '61) p 71

Structures, Production Engineering, Materials

Hypersonic fasteners use "exotic" forms and materials

Covers the completely new types of mechanical fasteners that will be needed on advanced aerospace structures. Discusses configurations and materials likely to be used, and new manufacturing processes to handle them.

by Irwin Stambler, Associate Editor

space/aeronautics 36/3 (Sep. '61) p. 56

Accessory Systems Materials, Test Engineering

Electric equipment checked for space environments

Describes testing of bearing materials and an electrical insulation system for use in extreme space environments. The insulation system and several of the bearing materials are reported to look promising.

by O. P. Steele III, Atomics International

space/aeronautics 36/3 (Sep. '61) p 75

Propulsion

Lithium propellant shows low combustion losses

Reports on a study of the advantages and disadvantages of lithium as a rocket propellant. Results provide some information on the Li-O-H reaction, show that existing thermodynamic data on lithium reaction products are unreliable, point to exhaust nozzle erosion and chamber burnout as serious problems.

by M. C. Hardin, A. I. Masters, Allison

space/aeronautics 36/3 (Sep. '61) p. 63

Structures, Materials, Production Engineering

Conveyorized grinding holds close honeycomb tolerances

Describes special conveyorized grinding equipment that covers 72-in. sheet or core widths while providing precise dimensional control. Outlines batch production method used with grinders for maximum efficiency.

by L. G. Brown, Mattison Machine Works

space/aeronautics 36/3 (Sep. '61) p 81

Test Engineering, Systems Engineering, Electronics

Digital-analog hardware simulation backs up Polaris design

Describes Polaris simulation program, consisting of six-degree-of-freedom trajectory routines programed for a digital computer and equivalent mathematical models applied to an analog computer and actual hardware.

by C. H. Kaufman, Lockheed Missiles & Space

space/aeronautics 36/3 (Sep. '61) p 67

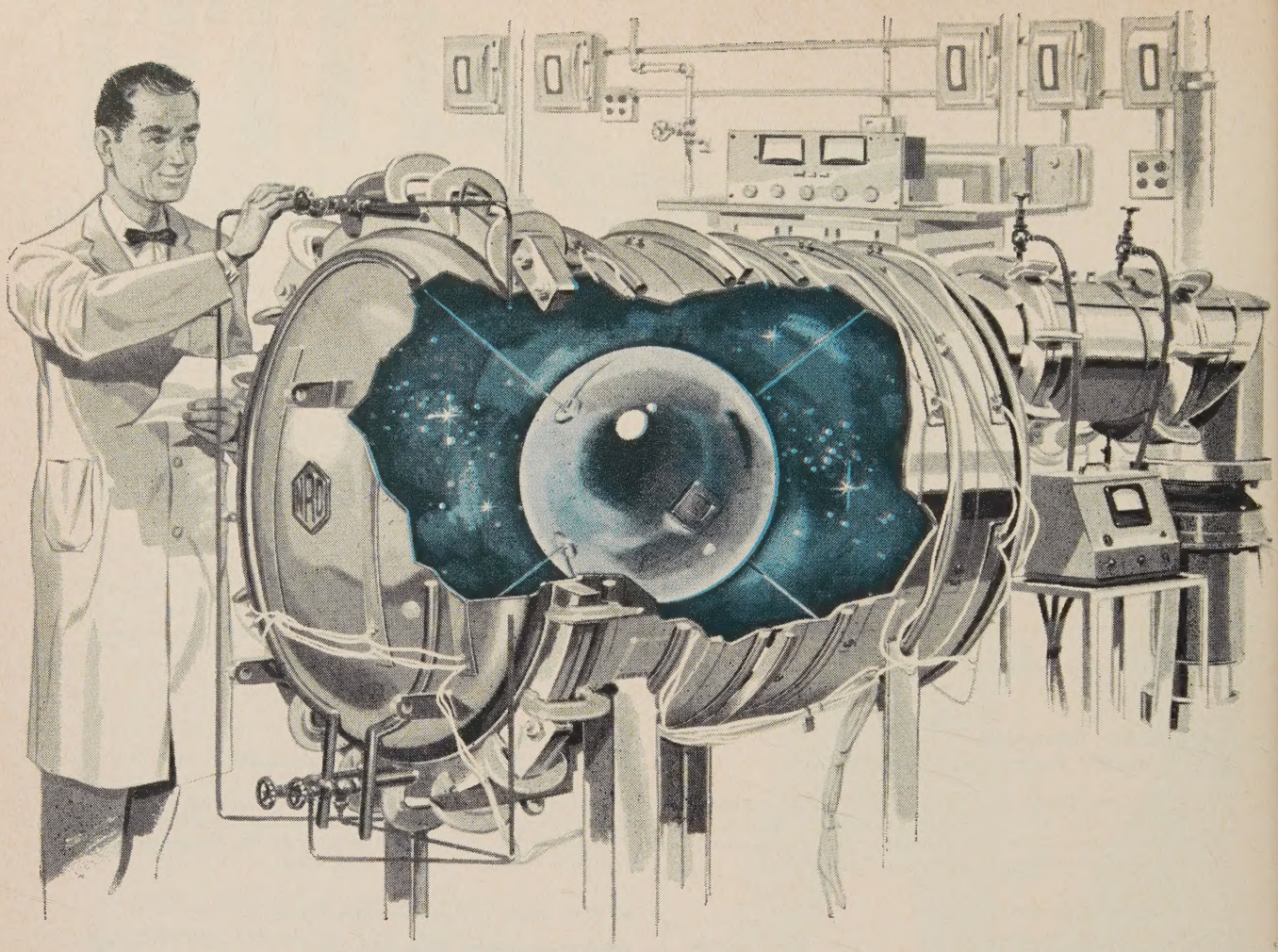
Materials, Production Engineering, Structures

90Ta-10W offers high temperature strength plus ductility

A report on the 90Ta-10W alloy. Includes preliminary design information, review of actual and potential applications, and data on the best methods of machining, forming, drilling, and threading.

by M. L. Torti, National Research

space/aeronautics 36/3 (Sep. '61) p. 87



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abstracts

continued from page 7

Electronics, Systems Engineering

Communications satellites: the technical problems

Reviews engineering difficulties faced by communications satellites. Discusses random low-altitude, 24-hour earth synchronous, and low-altitude equatorial orbits, concluding that random low-altitude type is most promising at today's state of the art.

by James Holahan, Electronics Editor

space/aeronautics 36/3 (Sep. '61) p 112

Electronics

Cryogenic gyros levitated by magnetic repulsion

Describes theoretical and experimental studies involving application of the basic facts of cryogenic gyro design. These studies are reported to go far toward solving the problems of magnetic field support configuration, operation in vacuum, and readout.

by J. T. Harding & R. H. Tuffias, Jet Propulsion Laboratory

space/aeronautics 36/3 (Sep. '61) p. 133

Electronics

Efficient heat transfer: key to reliable airborne electronics

Describes in detail the three modes of heat transfer, including heat transfer by phase change. Concepts and their application to the cooling of airborne electronics are analyzed, and the analytical methods themselves are derived.

by A. D. Kraus, Sperry Gyroscope

space/aeronautics 36/3 (Sep. '61) p. 122

Electronics

Ceramic filters replace IF transformers in command receiver

Discusses use of 455-kc ceramic filters in place of IF transformers in a fixed-tune HF command receiver for high-altitude balloons. Advantages are said to be low weight, simple IF circuitry, improved AGC, environmental ruggedness and good amplifier stability and selectivity.

by R. W. Fykman, G. T. Schjeldahl Co.

space/aeronautics 36/3 (Sep. '61) p. 143

Electronics, Test Engineering

High performance telemeter for minimum-payload space probes (Design Digest)

Design details of the Digilock telemetry system. Covers the system's computer-like encoder and gives functional block diagrams and photos. Describes the Digilock installation in USAF's Blue Scout, Jr.

by Bernard Kovit, Associate Editor

space/aeronautics 36/3 (Sep. '61) p 129

Systems Engineering, Ground Support, Electronics

Control display system for project Mercury

Description of the operations control center at Cape Canaveral for the Mercury project. Outlines sources of data, types of display, and duties of operations personnel.

space/aeronautics 36/3 (Sep. '61) p. 198

R&D Technical Handbook

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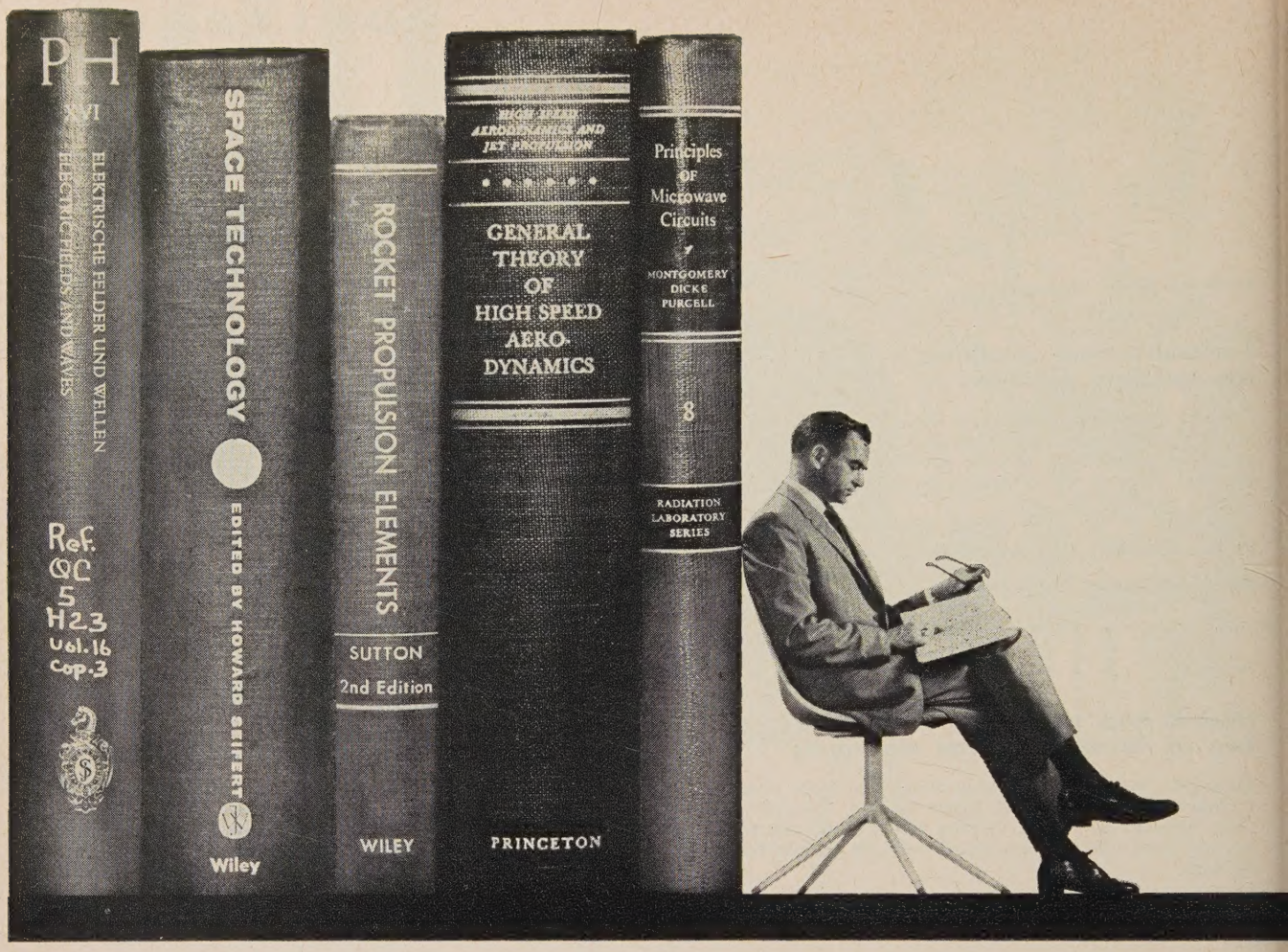

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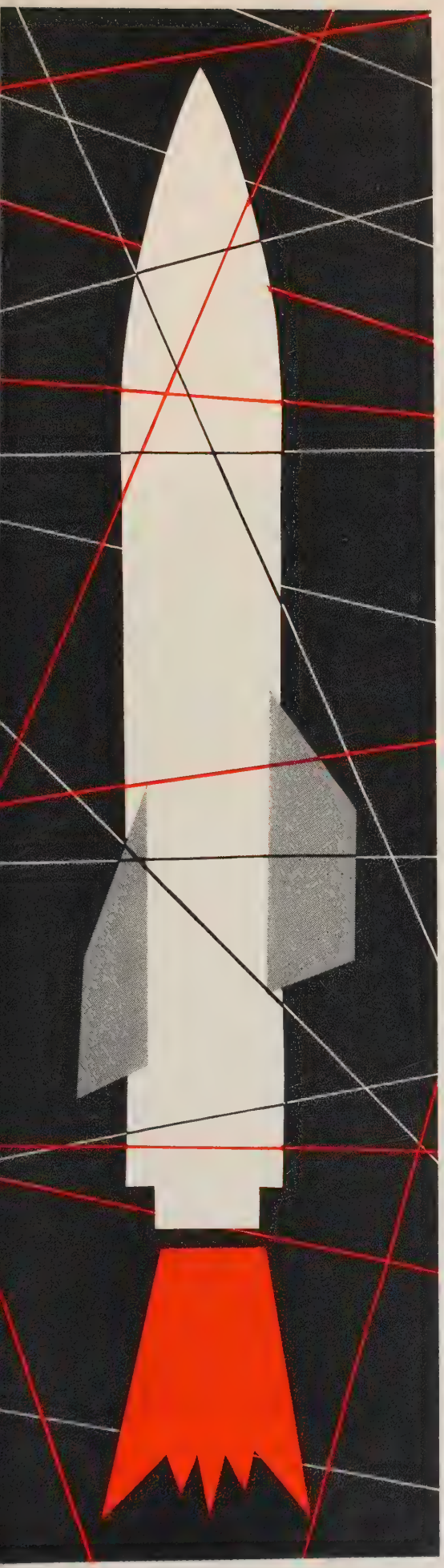

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now covered in MIL-W-16878D for military electronic hook-up wire

To electronic designers in the missile area, new opportunities are now open for improved wiring reliability. The recently issued "D" revision of Bureau of Ships' MIL-W-16878 specification for missile hook-up wire covers Du Pont TEFLON 100 FEP resin as insulation for continuous service up to 200°C.

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For more information about the properties and advantages of hook-up wire insulated with FEP resin, write to E. I. du Pont de Nemours & Co. (Inc.), Dept. SA-9, Room 2526T, Nemours Bldg., Wilmington 98, Delaware.

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BENDIX COUNTDOWN FOR SPACE

7

PNEUMATIC CONTROLS: Hot gas equipment is being developed for space control subsystems using rotary and linear actuation, reaction jets, and pneumatic computation. A complete subsystem is now being built at E-P under USAF contract.

6

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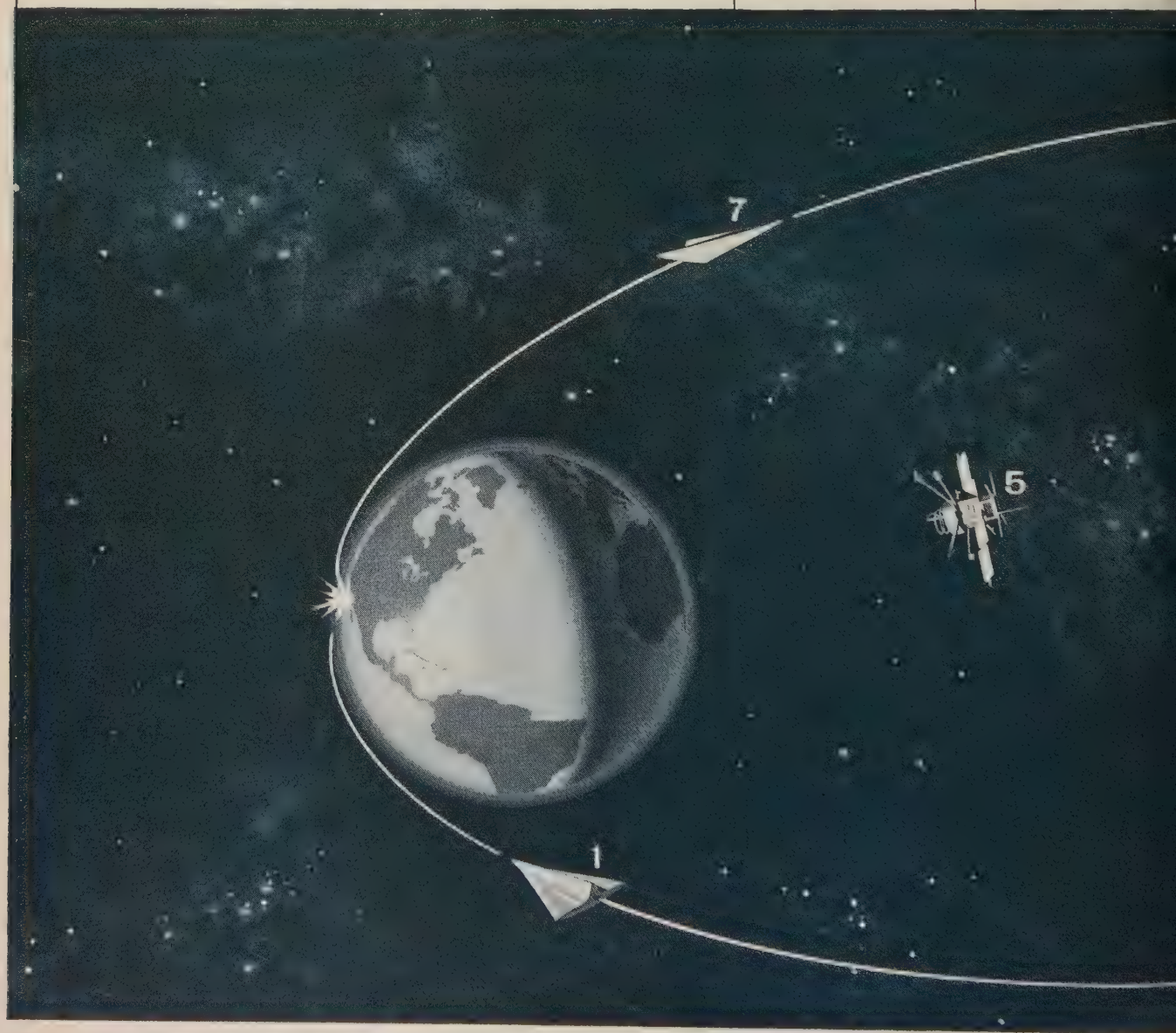

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5

ATELLITE CONTROL ND STABILIZATION: clipse-Pioneer has total in- ouse capability for producing pacecraft attitude-control ystems. In production: DVENT reaction wheels. In evelopment: sun-sensors nd star trackers.

4

STAR TRACKER SYSTEM: A system incorporating multiple star tracking heads, designed to operate without a protective dome in the environment of space; digital readout accuracy of ±5 arc seconds.

3

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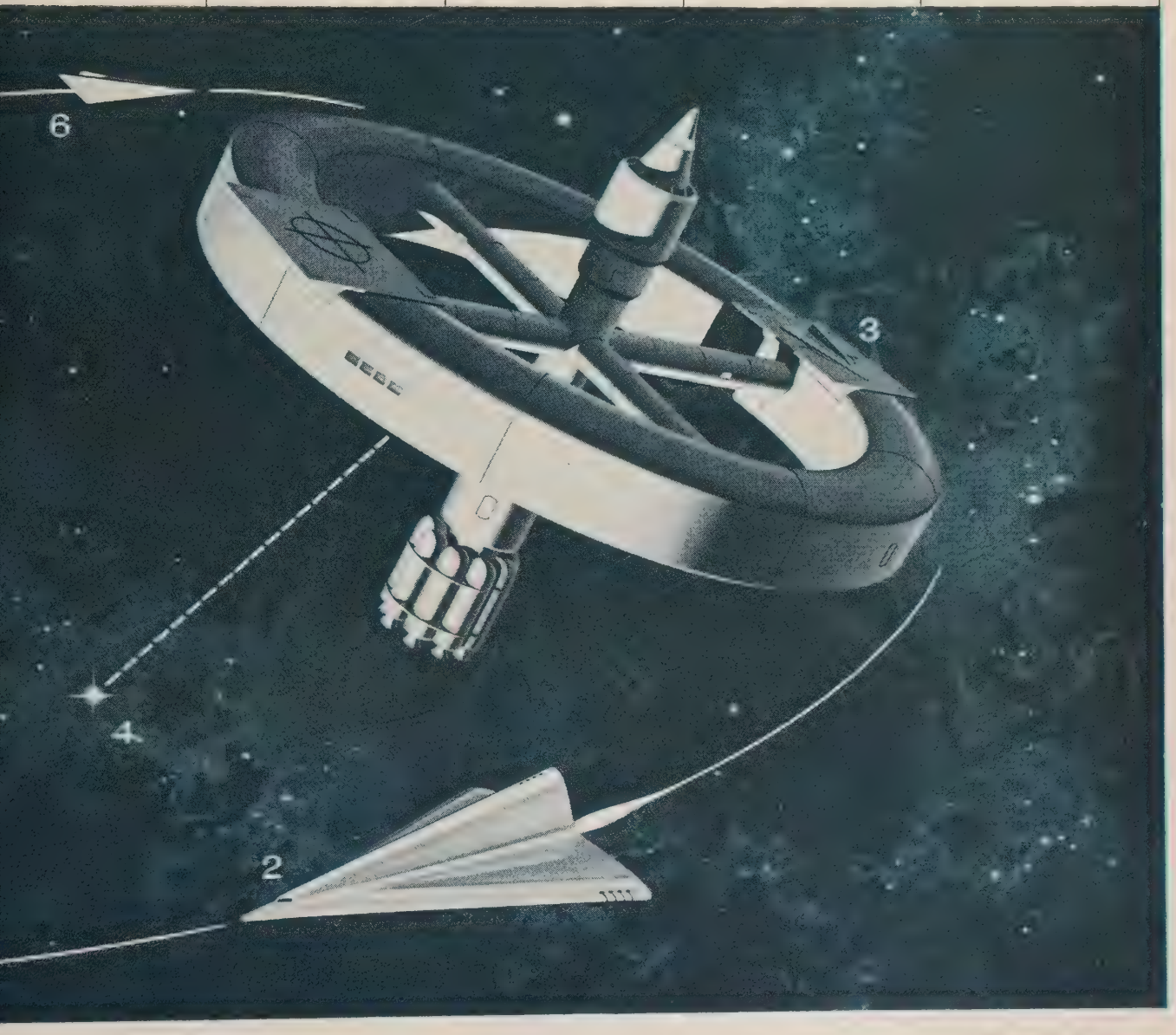
ADVANCED DISPLAYS AND CONTROLS: Development currently in progress. Human-factor display studies directed toward rendezvous, re-entry, energy-management. Electronic and optical devices will present correlated data with minimum panel space.

1

LETDOWN, APPROACH, LANDING: Safer, more reliable letdown and landing systems—such as inertially augmented flare and runway-alignment, computers, advanced instrumentation (including real-time displays)—are now being developed, flight-tested.



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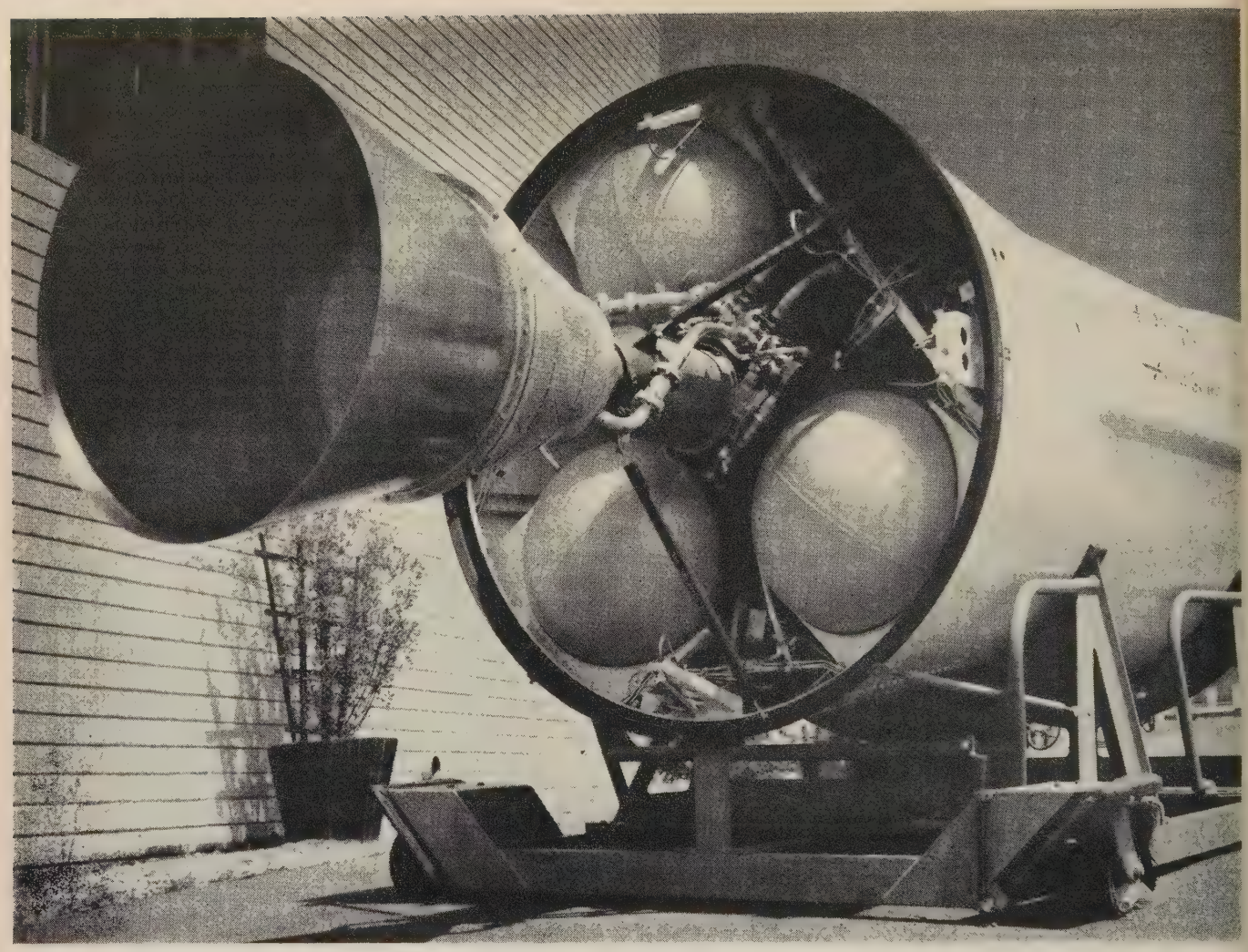

Three pressure bottles on Ablestar save 60 lbs. Nozzle extension is also titanium.

How Titanium pressure bottles reduce missile weight

The swing to light-weight, high-strength titanium metal for pressure bottles in the current generation of liquid fueled missiles provides conclusive proof of the design advantages and reliability inherent in titanium construction. Titanium vessels have sliced considerable poundage off missiles and thereby increased vital payloads. Here's why . . .

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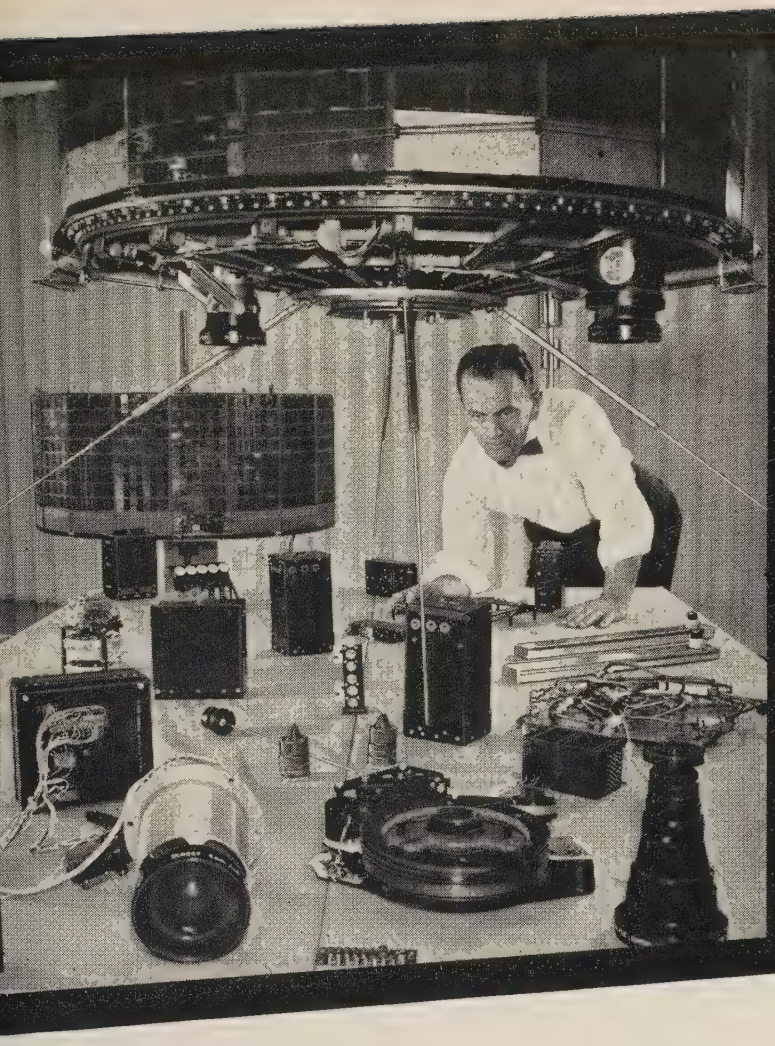

A cross-section of the 40 subsystems incorporating 3500 electronic parts which go into TIROS III are framed by two satellites. All components must be thoroughly tested, precisely integrated and must function perfectly if the satellite is to perform successfully.

NASA's Hurricane spotting TIROS III maintains projects' fine performance record

With the successful launching of TIROS III, meteorologists for the first time will see the total cloud formations and measure the radiative energy balance of hurricanes which plague the eastern coast of North and Central America each year. For TIROS III was launched at this time for precisely this purpose. From information gained from TIROS III, meteorologists may learn much more about the birth and life cycle of tropical storms.

TIROS III DESIGN

Although the spacecraft configuration is essentially the same as the previous two highly reliable TIROS satellites, TIROS III has two wide-angle cameras and the National Aeronautics and Space Administration has placed new omnidirectional IR sensors aboard to measure thermal radiation from the earth and sun.

THIRD OF A FAMOUS FAMILY

TIROS III is the third of a highly successful series of experimental weather satellites which were developed, along with the associated ground equipment, for the NASA, under contract with the Goddard Space Flight Center, by RCA's Space Center. All of them have established "firsts" in the United States' space program.

TIROS II established a longevity record for a complex satellite. Still operating after nearly eight months and over 3300 orbits, TIROS II has transmitted over 34,000 photographs to the ground. Aside from its impressive meteorological achievement, historians may well point to this long-term performance as the first to prove that a satellite system could operate reliably for so many months in a space environment thus proving the feasibility of operational satellites.

TIROS I was the first satellite, carrying advanced television equipment, which sent photographs of the earth's cloud cover to meteorologists. From TIROS I's 23,000 photographs, meteorologists found that satellites could be used for weather observation and analysis. The pictorial information is particularly useful in the two-thirds of the world from which few or no weather observations are now available.

CONNOTATIONS FOR THE FUTURE

The TIROS series has proved beyond a doubt that the peaceful uses of space will benefit all mankind. Six nations participated in the utilization of information from TIROS II and more will take advantage of TIROS III. RCA is also already at work on the camera systems and space power supply for NIMBUS, the next generation of meteorological satellites.

If you are a professional physicist, engineer, or mathematician and interested in participating in such challenging projects and stimulating team efforts, contact the Employment Manager, RCA Astro-Electronics Division, Defense Electronic Products, Princeton, N. J. All qualified applicants are considered regardless of race, creed, color or national origin.

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RADIO CORPORATION OF AMERICA

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UNIT-COLES CRANES

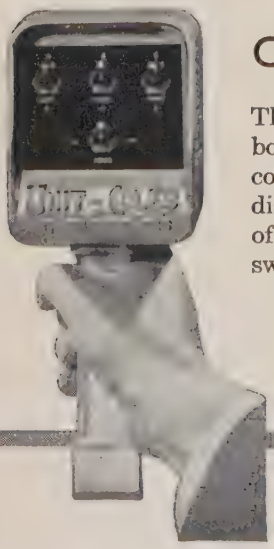
THE *Exclusive Choice* FOR HANDLING THE **TITAN**

Only UNIT-COLES Truck Cranes meet all the requirements for handling the mighty Titan. On every count . . . *accuracy*, *safety*, and *versatility* . . . the UNIT-COLES is far ahead of any other missile-handling device.

ACCURACY — All four crane motions - main load-hoist, auxiliary load-hoist, boom-hoist, and swing — have individual electric motors, powered by a variable voltage generator coupled to the crane's gasoline engine. The range of speeds is infinite, with all motions independent of each other. Load-hoist speeds are precisely controllable from less than a foot per minute up to 150 f.p.m. You get *true* pin-point accuracy without jerking or grabbing. There's no other method as precise or as simple to operate. Inexperienced operators quickly become "experts".

SAFETY - Men, machine and missile are fully protected at all times. An automatic Safe Load Controller warns of dangerous load conditions . . . stops and holds any load when it reaches the maximum safe working radius; self-resetting limit switches prevent dangerous over-travel of load and boom; there is "dead man" control of all operating functions; "fail-safe" automatic braking safely holds machine and load; many other safety features contribute to make the UNIT-COLES truly the "world's safest crane".

VERSATILITY - The crane is not restricted to the launching site. The UNIT-COLES Crane can be used for any lifting or transporting service upon demand, in contrast to specially designed, single-purpose machines. Write *today* for assistance with your special lift problems.



Only the UNIT-COLES has Remote Control

The exclusive lightweight remote control box shown here enables the operator to control all operating functions at any distance from the crane . . . even hundreds of feet away. It is equipped with control switches that duplicate the controls in the crane cab. To assure true precision for remote control operation, the remote engine throttle and the standard throttle have equal sensitivity of control. All remote controls are also of the "dead man" type.

THE WORLD'S SAFEST CRANE

UNIT-COLES

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Cleaning of components for liquid oxygen and liquid hydrogen (and other fuels) often raises the question: "*How clean is clean?*" In the case of Flexonics metal hose,

ducting, and expansion joints for both in-flight propulsion systems and ground support, here is our answer: "Not just hygienically clean, but *cryogenically* clean!" Flexonics has developed a unique "liquid honing" cleaning system, which produces results that exceed the industry's highest standards. Specify Flexonics for ducting assemblies and other flexible components. For the perfection and reliability you need, place the whole responsibility under one roof!

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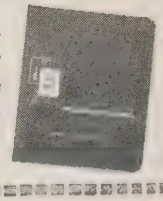
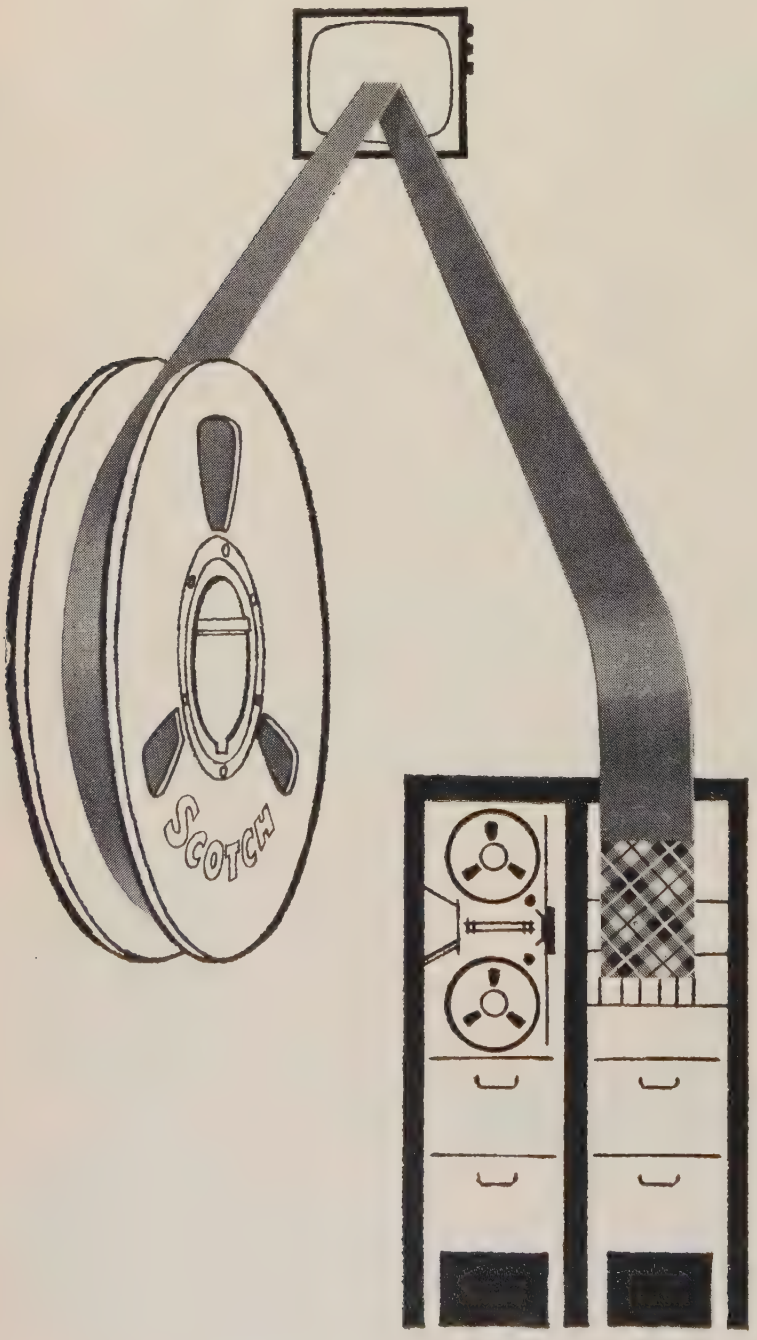
Please send me my personal copy of the big new Flexonics engineering guide and catalog of aero/space components.



THE TAPE THAT CHANGED TV FOR ALL TIME

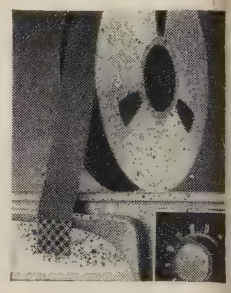
leads you right to rugged
SCOTCH® BRAND Heavy Duty Tape



THE TIE that binds television's top performer to instrumentation tape is strong—and it goes beyond the fact that the same expert team produces the best of both. "SCOTCH" BRAND Heavy Duty Tapes share a common heritage—and uncommon endurance—with "SCOTCH" BRAND Video Tape, the tape that puts a network TV show on the same "clock time" from Maine to California.

Similarities worth noting between the two: a similar high-temperature binder system, famous "SCOTCH" BRAND high potency oxides, a similar ability to resist tremendous speeds, pressures and temperatures while providing high resolution.

Let's look at the record of "SCOTCH" BRAND Video Tape and see what message it has for the user of instrumentation tape. On a standard reel of video tape like that shown here, some 1½ million pulses per second must be packed to the square inch—on a total surface area equal to the size of a tennis court. The tape must provide this kind of resolution while defeating the deteriorating effects of high speeds, pressure as high as 10,000 psi and temperatures up to 250°F.



The fact is that video tape must be essentially perfect. And it's a matter of record that thus far only the 3M experts have mastered the art of making commercial quantities of video tape that consistently meet the demands of the application.

Significantly, the high-temperature binder system developed for "SCOTCH" Video Tape is first cousin, only slightly removed, to that used in the Heavy Duty Tapes. It's this special feature that has given Heavy Duty Tapes their exceptional wear life.

The moral emerges: for tape that provides the best resolution of high and low frequencies under the severest conditions, turn to "SCOTCH" BRAND Heavy Duty Tapes 498 and 499.

They offer the high temperature binder system, plus the same high quality and uniformity that distinguish all "SCOTCH" BRAND Tapes. As the most experienced tape-makers in the field, 3M research and manufacturing experts offer tape of highest uniformity—from reel to reel and within the reel. Check into the other "SCOTCH" BRAND constructions: High Resolution Tapes 457, 458 and 459; High Output Tape 428; Sandwich Tapes 488 and 489; and Standard Tapes 403 and 408.

Your 3M Representative is close at hand in all major cities. For more information, consult him or write Magnetic Products Division, 3M Co., St. Paul 6, Minnesota.

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FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY
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We've been on our mettle for years staying on top of the metal manufacturing techniques required to build the precision structures of modern flight. We've done it with pioneer research... and with Rohr-invented machines such as stainless steel honeycomb core machines, numerically controlled milling machines and electrical discharge forming equipment. Today Rohr stands as **America's leading subcontractor to the aerospace industry.** Chances are our 10,000 craftsmen can be of help in your metals engineering and forming programs. For information please write Mr. A. R. Campbell, Sales Mgr., Dept. 65, Rohr Aircraft Corporation, Chula Vista, California.

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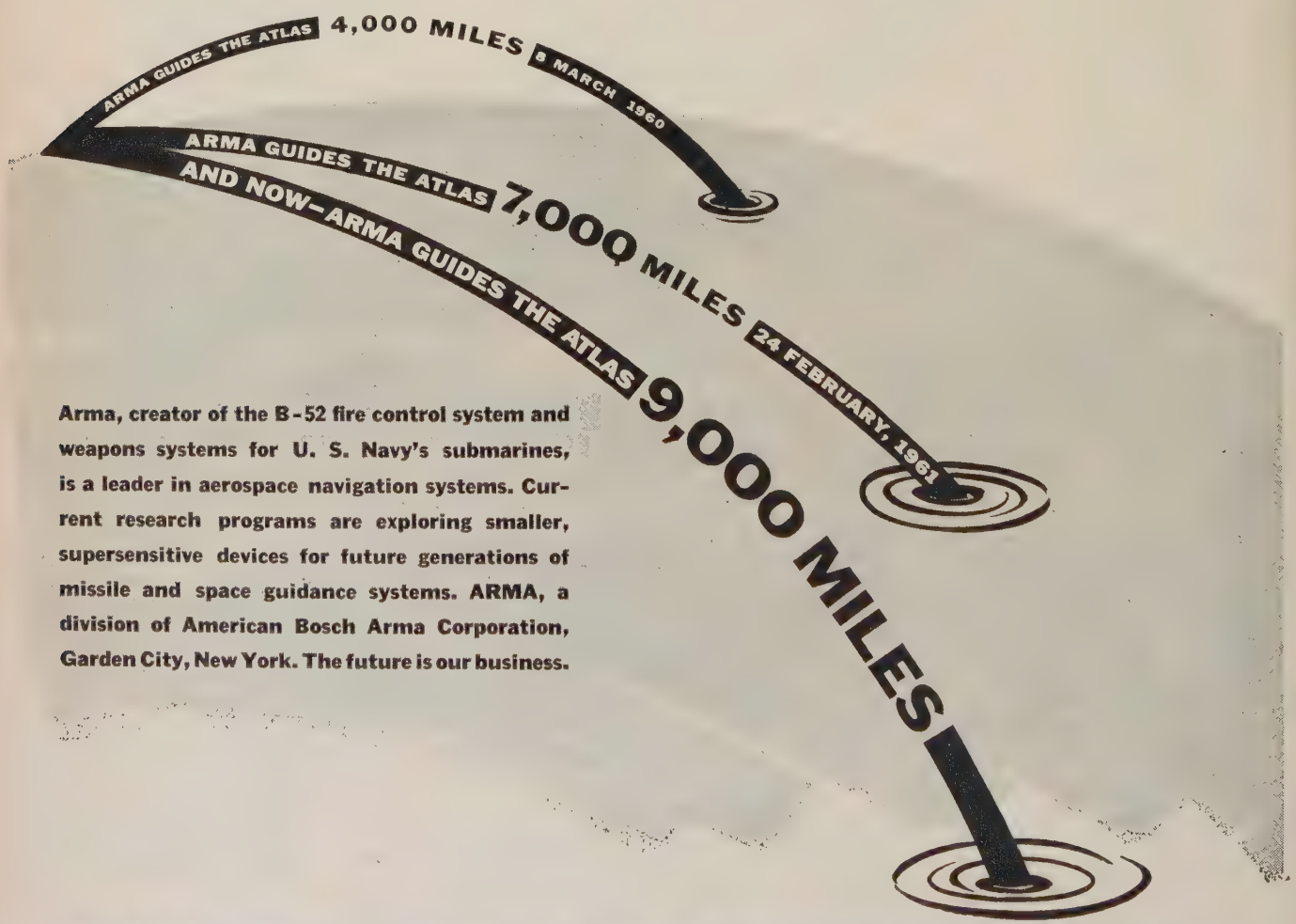
No. 10 on Reader Service Card

ARMA guides Air Force ATLAS in first full-range inertial flight

Cape Canaveral July 7, 1961. The Air Force announced the successful flight of an Atlas ICBM guided by the Arma inertial system 9,000 miles into the Indian Ocean.

A giant step in missile and space technology, this important feat of pin-pointing a target nearly half-way around the world demonstrated the phenomenal accuracy and reliability of Arma inertial guidance—America's first inertial guidance system of intercontinental range accuracy. This flight was another achievement of Arma inertial guidance which has performed successfully on every flight since the initial test in March 1960. Today the Arma system is in full production.

Arma inertial guidance provides our nation's ICBM arsenal with all the advantages inherent in inertial guidance—salvo firing, all-weather capability, immunity to outside interference, a minimum of costly ground equipment. Although specified for the Atlas missile, the Arma inertial system as a completely self-contained, self-correcting navigation system is adaptable to other aerospace programs and space exploration projects.

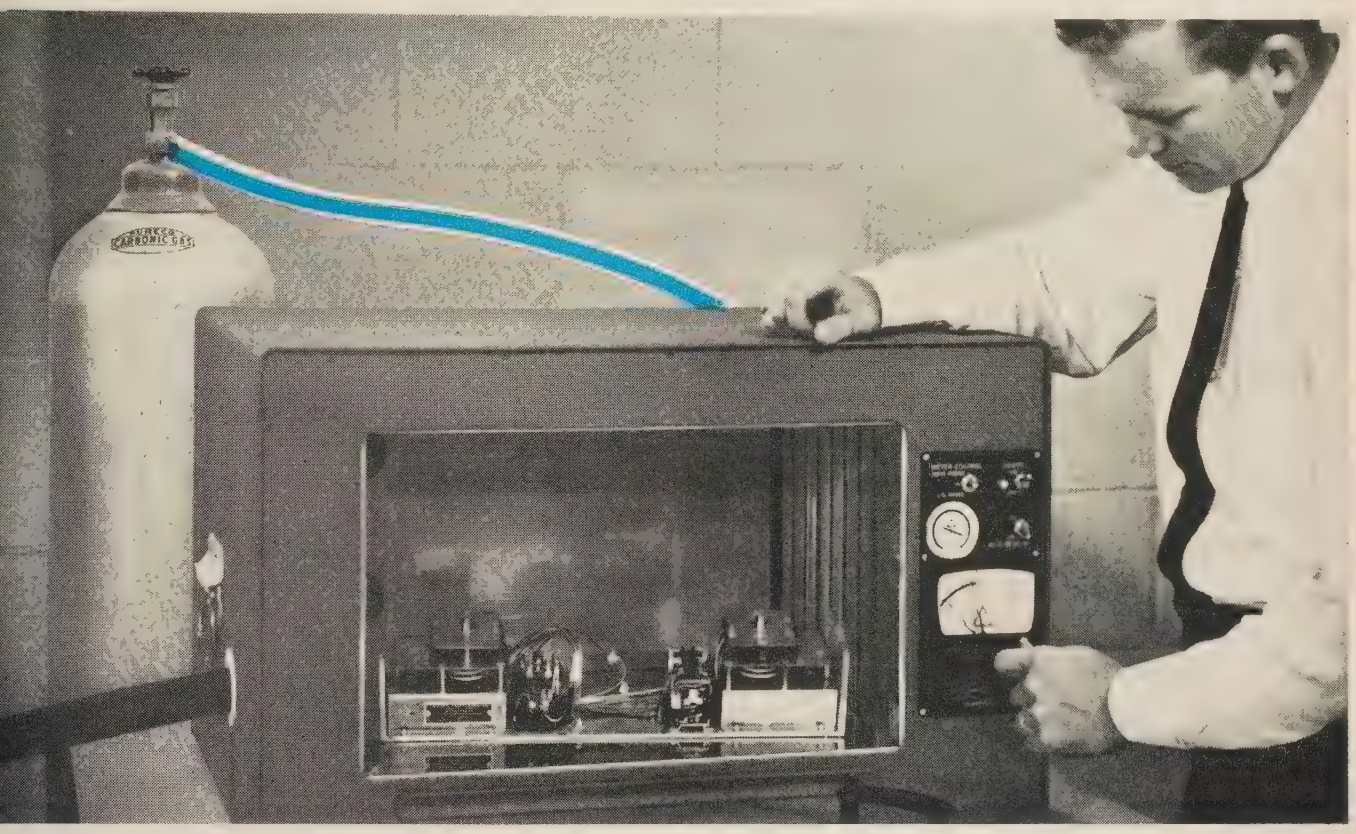

ARMA GUIDES THE ATLAS 4,000 MILES 8 MARCH 1960
ARMA GUIDES THE ATLAS 7,000 MILES 24 FEBRUARY 1961
AND NOW—ARMA GUIDES THE ATLAS 9,000 MILES

Arma, creator of the B-52 fire control system and weapons systems for U. S. Navy's submarines, is a leader in aerospace navigation systems. Current research programs are exploring smaller, supersensitive devices for future generations of missile and space guidance systems. ARMA, a division of American Bosch Arma Corporation, Garden City, New York. The future is our business.

AMERICAN BOSCH ARMA CORPORATION

THE PURECO CO_2 COLD BLUE LINE

for reliable, flexible, low-cost environmental testing



SAVE WITH PURECO CO_2 "BLAST COLD"

Extremely close tolerances possible

Test chamber temperatures with extremely close tolerances can now be easily achieved with the Pureco CO_2 "*Blast Cold*" process. Tolerances of ±½° are possible! This close control is obtainable by using specially designed cabinets and controls (as illustrated) and Pureco CO_2. Such pinpoint accuracy makes Pureco CO_2 liquid ideal for shock testing and hot and cold cycle testing.

Quick test chamber pull-down

This same simple Pureco CO_2 liquid direct injection process also provides refrigeration of unlimited capacity instantly . . . any time . . . anywhere. The Pureco CO_2 "*Blast Cold*" process can reduce temperatures from plus 500°F to —100°F in minutes. A minimum of mechanical devices in the system results in a high degree of reliability . . . there is virtually no danger of costly failures in the middle of a test.

Portable units now available

Since many environmental testing jobs are scattered around in plants, Pureco now supplies, in addition to cylinders, portable CO_2 bulk liquid units of 1000 lbs. capacity, as well as fixed units up to 60 tons or more capacity. Capital investment and maintenance costs are low . . . CO_2 receivers are normally supplied and maintained by Pure Carbonic on the customer's premises.

Have a trial "Blast Cold" demonstration

Pureco would like to demonstrate "*Blast Cold*" to you at *your* plant under *your* working conditions with no cost to you. Call your local Pureco representative or write:

PURECO CO_2

PURE CARBONIC

Pure Carbonic Company, A Division of Air Reduction Company, Incorporated
Nation-Wide Pureco CO_2 Service-Distributing Stations in Principal Cities
General Offices: 150 East 42nd Street, New York 17, N.Y.

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IT'S NEW IT'S FROM BRUNING

Five Hundred TRACING PAPER

Here is a new drawing medium truly worthy of your attention. Bruning's Five Hundred is a tracing paper *engineered* for draftsmen—developed after a decade of testing and proving by America's leading supplier to the engineering profession.

Five Hundred tracing paper has all the qualities that valuable drawings need and deserve. More, it has them in outstanding degree: the translucency, the permanence, the surface texture (each side slightly different for individual preference).

Today, with the costs of engineering drawings higher than ever before, the paper on which they're made should be the best obtainable—and the best is Bruning Five Hundred. Yet, this new drawing medium costs no more than conventional tracing papers.

TRY IT...PROVE IT

The real proof of this new tracing paper is, of course, your own test. So confident are we that Five Hundred will meet your highest expectations, we offer a large trial supply well below our cost. You have your choice of roll or sheets: simply mark the coupon.

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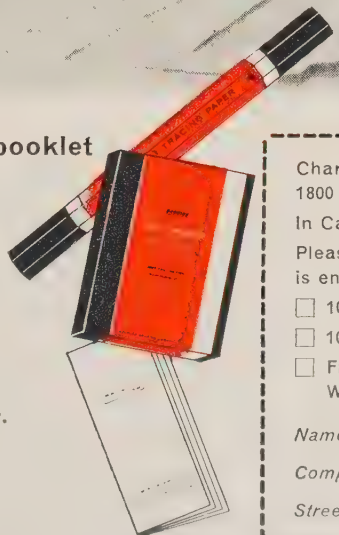

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Charles Bruning Company, Inc. SPA-9
1800 Central Road, Mt. Prospect, Illinois
In Canada: 103 Church St., Toronto 1, Ontario

Please send materials I have checked below. My dollar (s) is enclosed.

- ☐ 100 sheets Five Hundred tracing paper, 8½ x 11 ($1.00)
- ☐ 10-yard by 36" roll ($1.00)
- ☐ Free guidebook, "Tracing Paper Characteristics, and What They Mean to You"

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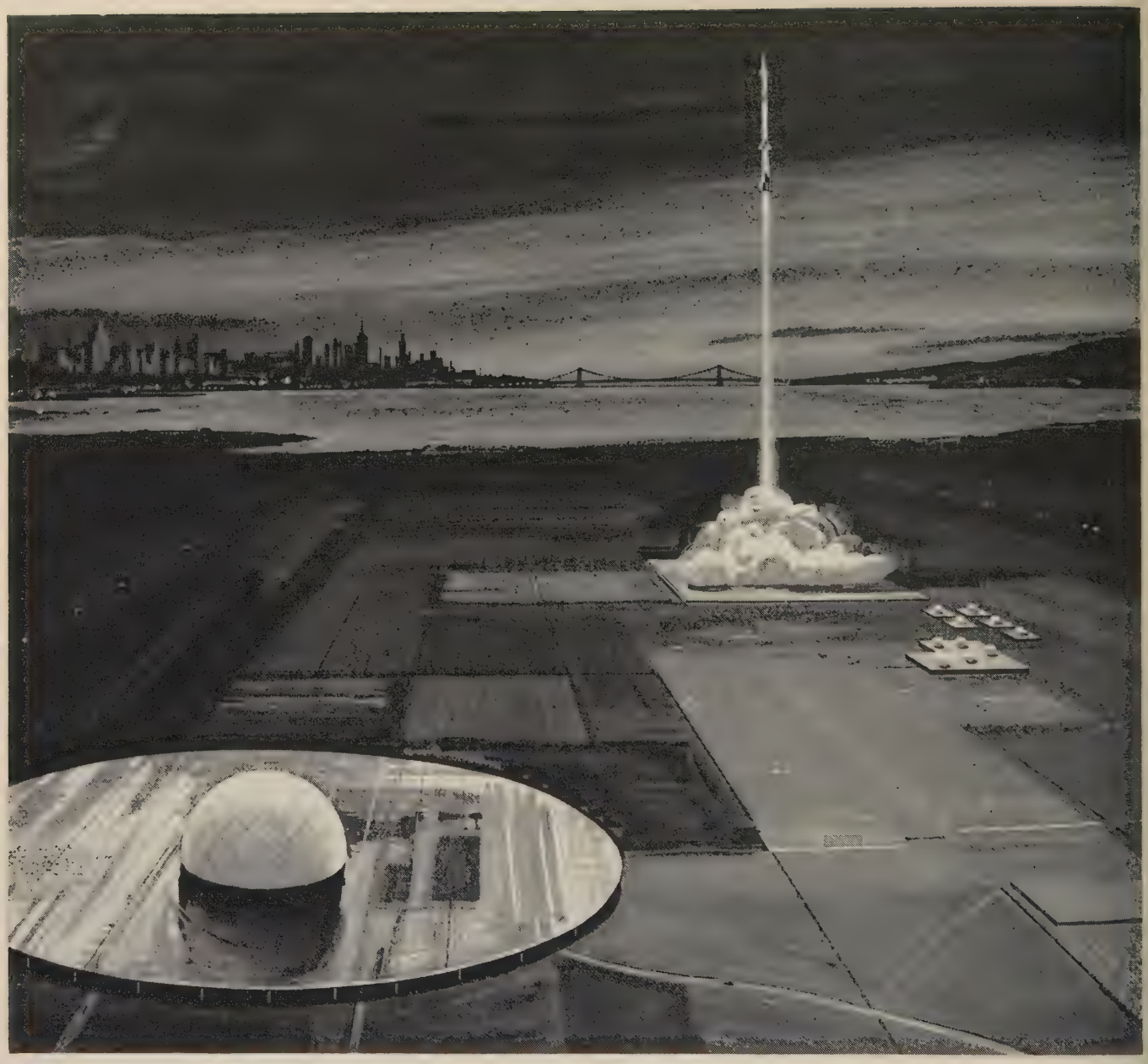

More than 450,000 pounds of thrust lifts the U. S. Army's Nike Zeus missile skyward in a cloud of vapor. The Nike Zeus missile being developed for the project by the Douglas Aircraft Company will be designed to intercept ballistic missiles traveling over 15,000 miles per hour, and destroy them at a safe distance from the defended area.

How do you stop an ICBM?

How do you detect, track, intercept—and destroy within minutes—an ICBM that is moving through outer space ten times faster than a bullet?

Bell Telephone Laboratories may have designed the answer: Nike Zeus, a fully automated system designed to intercept and destroy all types of ballistic missiles—not only ICBM's but also IRBM's launched from land, sea or air. The system is now under development for the Army Ordnance Missile Command.

Radically new radar techniques are being developed for Nike Zeus. There will be an acquisition radar designed to detect the invading missile at great distances. And a discrimination radar designed to distinguish actual warheads from harmless decoys that may be included to confuse our defenses.

The system tracks the ICBM or IRBM, then launches and tracks the Nike Zeus missile and automatically steers it all the way to intercept the target. The entire engagement, from detection to destruction, would take place within minutes and would span hundreds of miles.

Under a prime Army Ordnance contract with the Western Electric Company, Bell Laboratories is charged with the development of the entire Nike Zeus system, with assistance from many subcontractors. It is another example of the cooperation between Bell Laboratories and Western Electric for the defense of America.

BELL TELEPHONE LABORATORIES

World center of communications research and development

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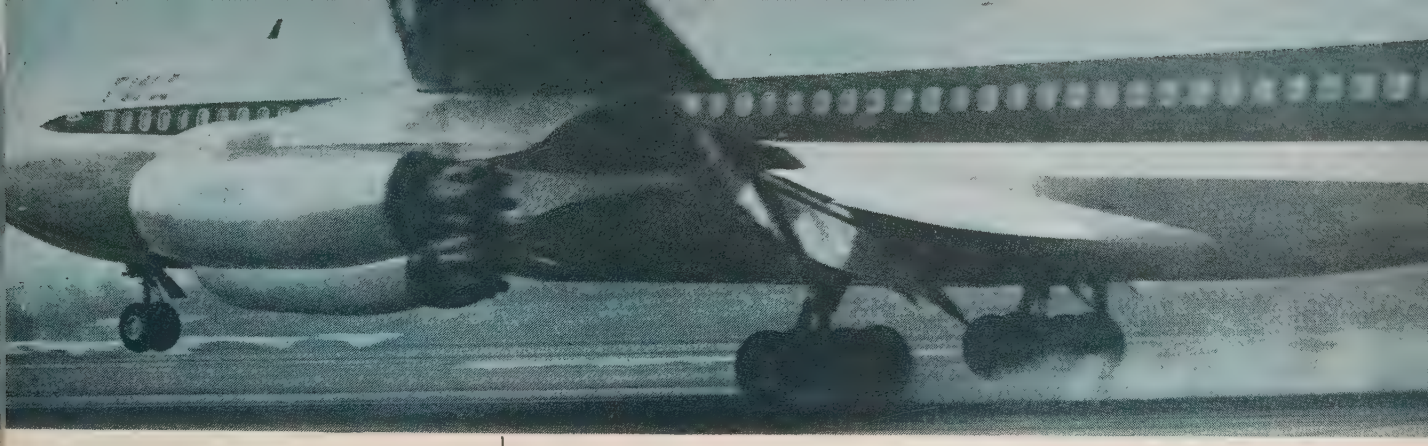


BENDIX BRAKES GIVE TWA 200,000 BRAKE STOPS WITH NOT ONE FAILURE

S. L. Higginbottom
Assistant Vice President
Engineering, Flight Test & Inspection
Trans World Airlines, Inc.

TWA

TRANS WORLD AIRLINES, Inc.

MID-CONTINENT INTERNATIONAL AIRPORT
KANSAS CITY 8, MISSOURI, U.S.A.

March 31, 1961

Mr. R. W. Whitesell
Director of Marketing
The Bendix Corporation
Bendix Products Division
South Bend 20, Indiana

Subject: Bendix Wheel and Brake Equipment

Dear Mr. Whitesell:

A review of the performance of the Bendix wheel and brake equipment on TWA's fleet of Boeing 707-131 aircraft indicates why we in TWA have a high regard for the Bendix equipment.

With more than twenty-three months of service representing approximately 25,000 landings (200,000 brake stops), we have yet to experience a brake failure. Similarly, wheel service has been excellent. The TWA flight crews likewise share our confidence.

We feel one reason for the excellent record is the effective and responsive service support. In addition to full time representation here at TWA's Mid-Continent Overhaul Base, field representation was provided throughout the training and indoctrination period at all of our Jet stations and have been promptly available on call whenever questions or problems occurred.

Very truly yours,

S. L. Higginbottom
Assistant Vice President
Engineering, Flight Test & Inspection

U.S.A. • EUROPE • AFRICA • ASIA

Mr. Higginbottom's comments coincide with those of most commercial, military, and business aircraft people.

Bendix brakes have wide appeal to all segments of the air transportation market. Pilots have full confidence in the brakes' dependable performance. Maintenance men like the reduced turnaround time. Controllers appreciate the lower cost-per-landing that results from use of the brakes.

The safety, dependability, and economy of these aircraft brakes stem from the superior designs, quality materials, and specialized background of Bendix—world's most experienced brake manufacturer.

Bendix PRODUCTS DIVISION South Bend, IND.

THE Bendix CORPORATION

Starfighters scramble on BFG fabric tread tires...

selected for ability to take 2-ton load variations, speeds to 270 mph.

A fast ship in the air, The Lockheed Starfighter is also mighty quick on the runway, with takeoff speeds ranging from 212 mph up to an extreme of 270 mph. The Starfighter's flexibility and its ability to carry heavy loads requires tires that can take two-ton load variations, and speeds up to 270 mph under adverse takeoff conditions. The BFG fabric tread design has proved it can stand up to these punishing conditions, reducing tread cutting and making tread separation virtually impossible. Multiple nylon plies are built right into the rubber tread stock. This reduces internal tread flexing and overheating. These tires are being supplied on the F104 for the U.S. Air Force, West German Republic, and Canada. For complete information, contact B.F.Goodrich Aviation Products, a division of *The B.F.Goodrich Company, Dept. . SA-9, Akron, Ohio.*

B.F.Goodrich aviation products

No. 14 on Reader Service Card

Elegance isn't everything

FORTY BILLION DOLLARS is a lot of money. That's what the President says it will take us to get to the moon. In a sense this staggering sum will be entrusted to the U.S. aerospace industry—and with it the nation's fortunes in the space race. If by the time we get to the moon we haven't appreciably narrowed the Russians' lead, some of the blame at least will fall on our industry.

Under the circumstances, it seems worth while to make a serious, objective analysis of the problem posed by the Soviet lead in space. What exactly has enabled the Reds to steal a march on us?

Of the many valid answers you can give to this question, there is one that concerns the aerospace industry more directly than all the others. This explanation has to do with the question of style in engineering.

Anyone who has thought about how engineers think and work knows that although you might not suspect it at first, there is such a thing as engineering style. Since an engineer is not a machine, he is influenced—when he's at work just as much as when he isn't—by his personal predilections, by the predilections of the group he's working with, and not least by the predilections of the people he belongs to. And since his work is highly intricate, it quite faithfully mirrors these predilections.

Now it can be argued that, by and large, the style of the American engineer favors the "elegant" solution—the design that meets the requirements with the least effort and leaves nothing to chance but provides for every conceivable contingency. In other words, a solution that is more likely than not to be complex is favored over a simpler one that merely gets the job done along the obvious, humdrum lines of least resistance. (That complexity as such does not faze the American engineer is not at all surprising in view of the fondness for gadgets of all kinds that certainly is one of our national characteristics.)

The reason why engineering style has to do with the space race is that the "elegant" design solution can at times turn out to be a handicap. In fact, there's little doubt that we have repeatedly handicapped ourselves in just that way.

Take the Russians' lead in booster power, which has plausibly been explained as largely due to our ability to design smaller and lighter—that is, more "elegant"—nuclear ballistic warheads. So here we are, with our elegant warheads and without that extra increment of booster power.

Naturally it would be silly to make an accusation out of the American engineer's preference for elegant solutions or to expect him to give it up. In the long run, it certainly does more good than harm, and in any case your style of doing things isn't something that can be switched on or off at will. But what the American engineer can do—and that includes every engineer in the aerospace industry, regardless of his position—is to be aware at all times of the fact that he does bring certain predilections to his work and these predilections can at times hamper him. In that way, he'll make sure that he isn't doing the Russians the favor of hamstringing himself before he has started.

GROVE FIRST!

INSTRUMENT ACCURACY IN A PRESSURE REGULATOR

Grove Low Flow Rate, High Pressure Reducing and Relieving Regulators. Even at very high differential and varying inlet pressures, Extreme Accuracy is possible because of the very large diaphragm-to-valve orifice ratios in Grove model 15 "loaders." Smooth Control when changing setting, without overshoot or undershoot, is achieved by super-sensitive handwheel adjustment. The simplicity and quality designed into Grove hand loaders gives Longer Service Life with minimum maintenance. Although designed primarily for panel mounting in test facilities, the Reliability, accuracy and light weight of Grove loaders qualifies them for service in airborne vehicles. Offered with motor actuators for remote operation. Wide range of models to serve from 0 psi to 6000 psi. Send for Technical Presentation 125-C, Rev. 1. *Another Way Grove Sets Regulator Standards for Others to Follow*

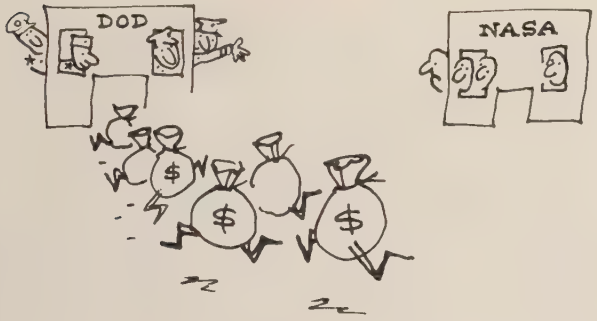
GROVE REGULATORS **GROVE VALVE AND REGULATOR COMPANY**

a subsidiary of Walworth • 6529 Hollis Street, Oakland 8, California

Cutbacks in civil space programs?

Now that Congress has voted President Kennedy the extra $3.5 billion in defense appropriations he sought to meet the crisis over Berlin, Washingtonians are wondering whether the increase in the military budget for fiscal '62 will result in a slight downgrading of civil space activities.

There's no doubt that total government income for the current fiscal year will



fall far short of expenditures. Some estimates place the difference at $6 or $7 billion. And the President, who promised that the 1963 budget would be balanced (even if he had to request higher taxes) seems reluctant to ask for a tax hike this year for fear of inhibiting the nation's recovery from the recession.

Congress has already provided everything the Chief Executive wanted in the way of extra defense money. But there's grumbling on Capitol Hill that non-defense spending should be reduced to compensate for the higher military outlays.

The President will be under Congressional pressure to have the Budget Bureau withhold some of the non-defense funds already voted before the Berlin situation deteriorated. Space money voted for NASA may also be reviewed.

The President went before Congress in May to point out the need for added NASA money to put a man on the moon before 1970. Both Houses voted him every cent he sought.

Congressional leaders and Mr. Kennedy still want an expanded space program, but priorities are changing. R&D on military uses for space will go on, but there may be some cutbacks in spending on space hardware this year.

Future of bomber funds uncertain

There are still no firm indications whether defense Secretary Robert S. McNamara will change his mind about using the extra half-billion Congress voted to maintain bomber production.

The Moscow Air Show contained a number of surprises in the way of bombers and fighters. The display caused President Kennedy to call a special meeting of the National Security Council, but McNamara has shown no disposition to use the voted funds to reorder Boeing B-52s and Convair B-58s or to step up the Mach 3 B-70 beyond the current order for four prototypes.

Gen. Maxwell D. Taylor, the President's military representative, who has long contended the U.S. was not prepared to fight limited wars, has succeeded in convincing Mr. Kennedy. The $3.5 billion voted last month will be used for conventional weapons, Republic F-105 fighter-bombers to support

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Careers in a New Era of Space Technology Leadership

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Today Space Technology Laboratories, Inc., is engaged in a program of diversification and planned growth.

Programs. Research, development, design, and construction of three Orbiting Geophysical Observatories for NASA. Systems engineering support and technical consulting services for the Army Advent program. Systems engineering and technical direction of the Atlas, Titan, and Minuteman weapon systems for the Air Force. Original and applied research in a broad spectrum of disciplines: particle physics, solid state theory, guidance, space physics, communication theory, propulsion and power, and electromagnetic systems in the infrared, ultraviolet and microwave regions.

Facilities. Presently under construction on a 110-acre site at Redondo Beach, near Los Angeles International Airport, is the STL Space Technology Center comprising ten buildings specially designed for research and development in missile and space systems, for the fabrication and environmental test of subsystems and components, and for the production of scientific and technical devices derived from STL's sustained research program. These new facilities will be augmented by the STL research and fabrication installation at Canoga Park, California.

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ground troops, and Lockheed C-130 prop-jet transports to augment airlift capabilities.

Secretary of State Dean Rusk and McNamara are now trying to prod America's NATO allies into spending more themselves for ground troops and conventional weapons, thereby strengthening the shield in NATO's "sword and shield" concept.

But except for the B-52 extra ground alert and the new funds for Polaris, Minute-man, Atlas, and Titan missiles requested in the first Kennedy revision of the Eisenhower defense budget, the Russian air display and the Khrushchev threat to Berlin have resulted in no new effort to sharpen the "sword"—the USAF's Strategic Air Command.

Gen. Curtis E. LeMay, AF Chief of Staff, is a firm believer in using available weapons and would prefer to see the B-52 production line at Wichita continue without a break. This is basically what the extra $525 million voted by Congress was designed to do, even though the AF would have the option of using some of this cash for B-58s.

McNamara seems determined not to use any of the extra bomber money, but his thinking may change under LeMay's influence.

SST to cost $12.6-20 million a copy

NASA, FAA, and the Defense Department are now agreed that a Mach 3 commercial airliner can be ready by 1970-71 but that the U.S. will have to assist private planebuilders in the cost of development.

Latest estimate by the three agencies is that the sales potential for such an airplane is "upwards of 200" throughout the world, although various producers have come up with a market ranging from 75 to 450 supersonic jetliners during the 1968-1975 period.

Congress voted FAA the $12 million it asked for development of an SST (supersonic transport) over the mild objections of an airpower supporter, Sen. Stuart Symington of Missouri. Symington objected to the release of the SST money while the Mach 3 B-70 program remained unchanged from the four-prototype level imposed by DOD in March.

In addition to FAA's $12 million in R&D money, NASA plans to spend about $8.5 million on internal Mach 3 studies this year. Much of the USAF's work on the B-70 will be applicable to the SST.

DOD's McNamara, NASA Administrator James E. Webb, and FAA Administrator Najeeb E. Halaby have reached several other conclusions about the SST:

- Competition between manufacturers of engines and airframes will be used to maximum advantage.
- Direct U.S. financial assistance will be provided only until industry can carry on alone.
- Airlines must participate actively in the SST development program.
- The U.S. must take action to recover as much of its direct outlays as possible.

The three agencies place the cost of an SST at something between $12.6 and $20 million a copy. It will have a range of 3500 nautical miles, cruise at 2000 mph at 70,000 ft, weigh about 400,000 lb, and be 200 ft long. Wing span will be about 100 ft and payload will be 100 to 150 passengers.

Biggest problem, the three agencies feel, will be sonic booms, even though the SST is expected to be no noisier than current jetliners at subsonic speeds.

Tri-agency researchers have discovered the manufacturers want a brand-new turbofan engine capable of providing maximum thrust at altitudes over 30,000 feet. Other major R&D activities will have to include work on a wing which will be efficient at high and low speeds.

NEW SYSTEM OFFICES TO HANDLE HIGH-PRIORITY PROJECTS FOR FAST RESULTS

Air Secretary Eugene M. Zuckert has ordered the creation of system offices (Systos) to handle high-priority projects. About 10 such offices, headed by an AF technical officer with the rank of colonel or above, will be created initially.

So far only Minuteman, Titan, Atlas, and the B-70 have been picked for the Systo approach. Other projects considered include Dyna-Soar, Midas, Samos, Sky Bolt, satellite interceptors (SAINT), solid boosters, and 465-L, the SAC control system.

Set 24-hour target for resolving problems

The AF is hoping that the Systos will shorten the time for decisions on major weapon systems. Instead of waiting for rulings by the Weapons Board, the Air Council, the USAF Chief of Staff, and Zuckert, the Systos (located in Washington) will immediately take up problems uncovered by the Ballistic Systems Division at Inglewood or by AF Systems Command headquarters at Andrews AFB, Md., with whatever Pentagon board is appropriate.

The Systos will deal with a secretariat which serves Zuckert's Designated Systems Management Group (DSMG) and the Air Staff's Systems Review Board. Normally the Systos will try to reach decisions with the Review Board in 24 hours and then submit them to DSMG for approval by Zuckert. If time is insufficient, the Systo officer could deal directly with DSMG.

Generals Bradley and Wilson fill top slots

Zuckert has also rearranged the Air Staff to tie in with the recently created AF Systems Command and AF Logistics Command.

The USAF's top echelon now has Lt. Gen. Mark E. Bradley Jr. as Deputy Chief of Staff (Systems and Logistics) and Lt. Gen. Roscoe C. Wilson as DCS (Research and Technology).

The revisions under Bradley make Maj. Gen. William O. Senter the Assistant DCS for Logistics and Maj. Gen. Joseph R. Holzapple the Assistant DCS for Systems.

Also under Bradley will be Brig. Gen. Milton B. Adams as director of systems acquisition (responsible for development, procurement, production and review of all systems at the staff level) and Brig. Gen. M. C. Smith as director of systems services (in charge of missile range and special ground environment support, standardization and engineering, technical and industrial reports, and equipment support).

Wilson's chief aides will be Maj. Gen. Victor R. Haugen, Assistant DCS (R&T); Maj. Gen. Marvin C. Demler, director of advanced technology; Maj. Gen. William B. Keese, director of development planning; and Brig. Gen. Ralph L. Wassell, director of research.

These men will monitor the AF's research program, prepare long-range research objectives, and coordinate R&D with other Government research groups.

Latest $3.5 billion addition (including some funds for the civil defense activities newly assigned to the Pentagon) will add the following limited war planes and missiles to the various services' buying:

- **Army's procurement budget is now $2.5 billion. The extra $552 million will include $36.7 million for airplanes (Iroquois helicopters, Sioux observation helicopters, Seminole utility planes, Raven helicopters and Caribous and Mohawks) and $33.8 million for missiles (Honest Johns, Nike-Hercules, and Hawks).**
- **Navy's procurement money amounts to $6.5 billion. The extra $709 million includes $281 million for planes (A4D-2Ns, F8U-2Ns, F4H-ls, HU2K-ls, HSS-2s, P3V-ls, S2F-3s and GV-1 turbojet Marine refueling aircraft) and $262 million for missiles (Sidewinder, Bullpup, Tartar, Terrier, and Talos).**
- **USAF's new procurement total (aside from the half billion voted for bombers) is $7.6 billion. The additional $425 million includes $241 million for planes (F-105Ds, C-130Bs and Es, and spares to keep more B-52s on ground alert) and $62 million for missiles (Falcons, Bullpups, and Sidewinders).**

AIR FORCE TIGHTENS UP ON MONEY AND DELIVERY

Although the Air Force foresees no easy solution to its contracting and procurement problems during the 1960 decade, it expects to devote as much effort to this area as to research and development.

Lt. Gen. Mark E. Bradley, Jr., Deputy Chief of Staff (Systems and Logistics) says that future USAF procurement will entail:

- Clear statements of requirements, from which contractors will not deviate and thereby run up costs.
- Closer study of types of contracts, with emphasis on fixed-price agreements permitting fair profits, but eliminating windfalls.
- More intense review of proposals with respect to costs and time. The best proposal will not be ordered into production if its cost is too high or it will take too long to become operational.
- Full scrutiny of engineering changes, especially those that run up costs or tend to delay a project.
- Renewed emphasis on shorter time for development. The AF doesn't want to inhibit scientists by unreasonable deadlines but it can't wait for perfection.
- Pinpointed cost estimates. CPFF contracts tend to result in overruns. Fixed-price agreements mean a greater risk for the contractor but may result in better profits if incentive features are included and the program is well managed.

DOD looking into sea launching costs

Neither NASA nor the Pentagon seems ready to support the Navy's concept of launching satellites at sea, although DOD's research and engineering office plans to make a cost analysis of developing the technique.

NASA has pointed out that the "price appears too high in terms of cost of construction and operation, logistics problems, and political complications."

The House Space Committee feels that mobile sea launch has some advantages, mostly in economy of operation for individual shots that now require doglegging the vehicle trajectory.

Navy proponents contend such a capability could be built up at a relatively low cost by converting a few ships and floating drydocks. These ships, they add, would also serve for military communications, reconnaissance and anti-satellite work.

Critics maintain that a whole fleet would have to be converted, at prohibitive cost, to provide a full capability.

NASA is looking around for a program manager to administer the Apollo three-man capsule-to-the-moon program in preparation for the award of the contract around the end of the year.

(The post was offered to the Navy's Vice Adm. William F. Raborn, who managed Polaris, but he has turned the offer down.)

Industry is expected to handle about 85 per cent of the Apollo project and 15 per cent will be spent in-house. Studies by Convair, GE, Martin and NASA itself indicate that the capsule will weigh in at between 20,000 and 25,000 lb.

Although the R&D production order for the Apollo capsule is due by January, the space agency has no definite schedule on tests as yet. Target date, set by President Kennedy, is "before 1970."

On following pages . . .

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- Astronomers claim project Westford will hamper observations 43
- Project Star's nuclear reactor converts heat to electricity 43

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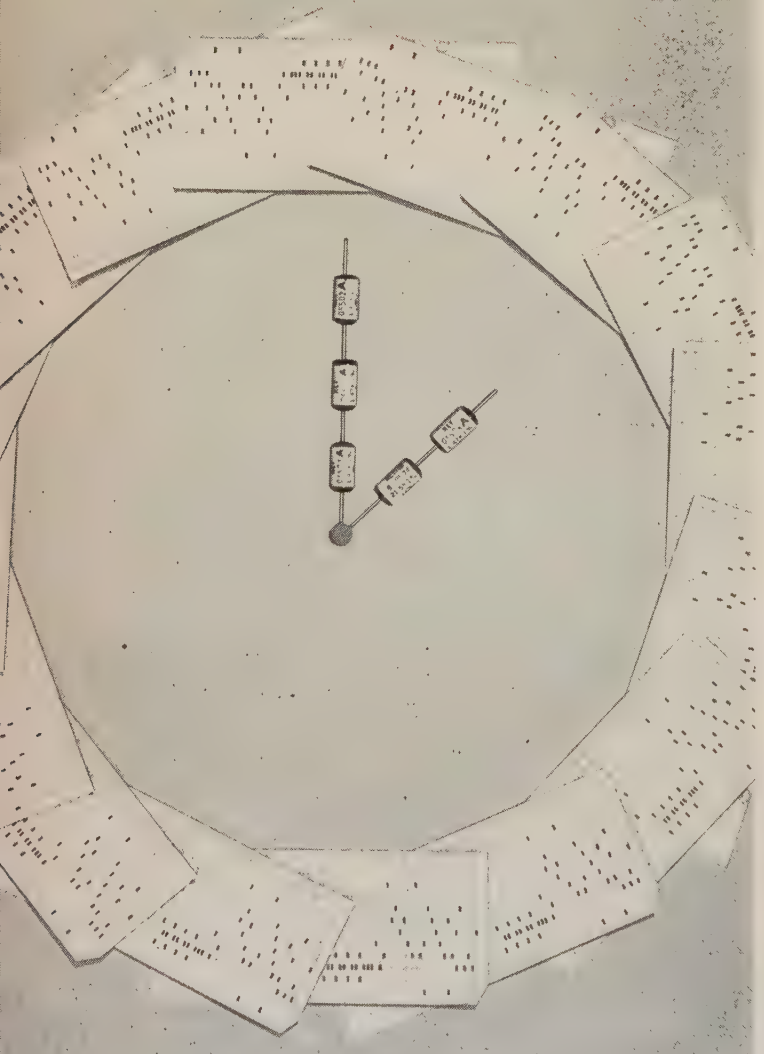

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Tolerance	±1%
Resistance range	10 ohms to 100K ohms
Temperature coefficient	± 25 PPM/°C ± 50 PPM/°C ±100 PPM/°C } −55° to +145° C
Type	Evaporated metal film
Construction	Hermetically sealed glass, helium atmosphere
Leads	Weldable (gold-plated Dumet)
Body Length	.281 ± .030″
Body Diameter	.155 ± .015″

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PACKAGES SHOW TRUE COST OF WEAPON SYSTEMS

Charles J. Hitch, Assistant Defense Secretary (Comptroller), who evolved the concept of program packages to determine the true cost of weapon systems, says the first packages will show up in the fiscal '63 budget.

Hitch and Budget Bureau Director David Bell feel the package technique is a better way to determine what weapons to fund than the previous system of arbitrary budget ceilings.

Under the new system, the services submit alternative forces and programs to DOD. Newly conceived weapon systems do not compete for funds within their own service alone, but are judged against competitive weapons in their program package. Total cost of each program is shown for a minimum of five years.

First package, involving Central War Offense Forces, has already been completed by the Army, Navy, and Air Force. The next two, Central War Defense Forces and General Purpose Forces, are also ready for analysis by Hitch and McNamara.

Others, with an August 31 target date, are sea and airlift forces, research and development, service-wide support, the Military Assistance Program, Reserve and National Guard Forces, and classified projects.

Scope of packages

The Central War Offense Forces package includes the B-52 (with Hound Dogs, Quails or decoy missiles), B-58s and B-47s, tanker aircraft, B-70s', Thor, Jupiter, Regulus, Polaris, Titan, Atlas, Minuteman and the communications and control systems needed to direct the strategic weapons.

Central War Defense Forces include various USAF interceptors, Dewline, Ballistic Missile Early Warning System, radar picket ships, Army surface-to air missiles like Nike, Missile Master, Sage, bomb alarm systems, the NORAD setup at Colorado Springs, and the electronic systems linking the various defense setups.

General Purpose Forces, the largest of all, covers the Tactical Air Command, reconnaissance planes and drones, KB-50 tankers, Matador and Mace missiles, Army ground troops, and the command and control systems that link units and weapons used primarily for limited wars.

• Martin-Orlando received its first production order from the USAF for the nuclear warhead version of the GAM-83B Bullpup missile. The B is larger and has a longer range than conventionally tipped GAM-83s.

• Bendix will install $2.9 million worth of electronic equipment for the Army Signal Corps aboard the Navy's Kingsport Victory. Equipment will be associated with the Army's Advent communications satellite.

• General Electric-Evendale received more than $21 million in three USAF contracts to produce and improve J79 Turbojets.

RUSSIA'S SECOND ASTRONAUT SET NEW RECORDS

Russia's second astronaut, Maj. Gherman S. Titov, completed 17 earth orbits in a 25-hr 18-minute flight, traveling 435,000 mi in the 10,400 lb Vostok II. Orbital time was 88.6 min, with a 160-mi apogee and 111-mi perigee, at 17,750 mph. Maj. Gagarin went higher, 188 mi, in the first orbital flight, but the latest Russian achievement set new records for speed, distance and weightlessness in the space derby.

Man-in-Space Scoreboard

	USSR	USA
Flights	2	2
Type	Orbital	Sub-orbital
Orbits	1; 17	0; 0
Time	108 min; 25 hr, 18 min	15 min; 16 min
Distance	approx. 25,000 mi 435,000 mi.	302 mi; 303 mi
Weightless period	89 min; 25+ hr	5 min; 5 min

Two trial orbital Mercury flights

Present US plans call for two trial orbital flights of Mercury capsules, one with a dummy and one with a chimpanzee aboard, before a man will be put into orbit. The

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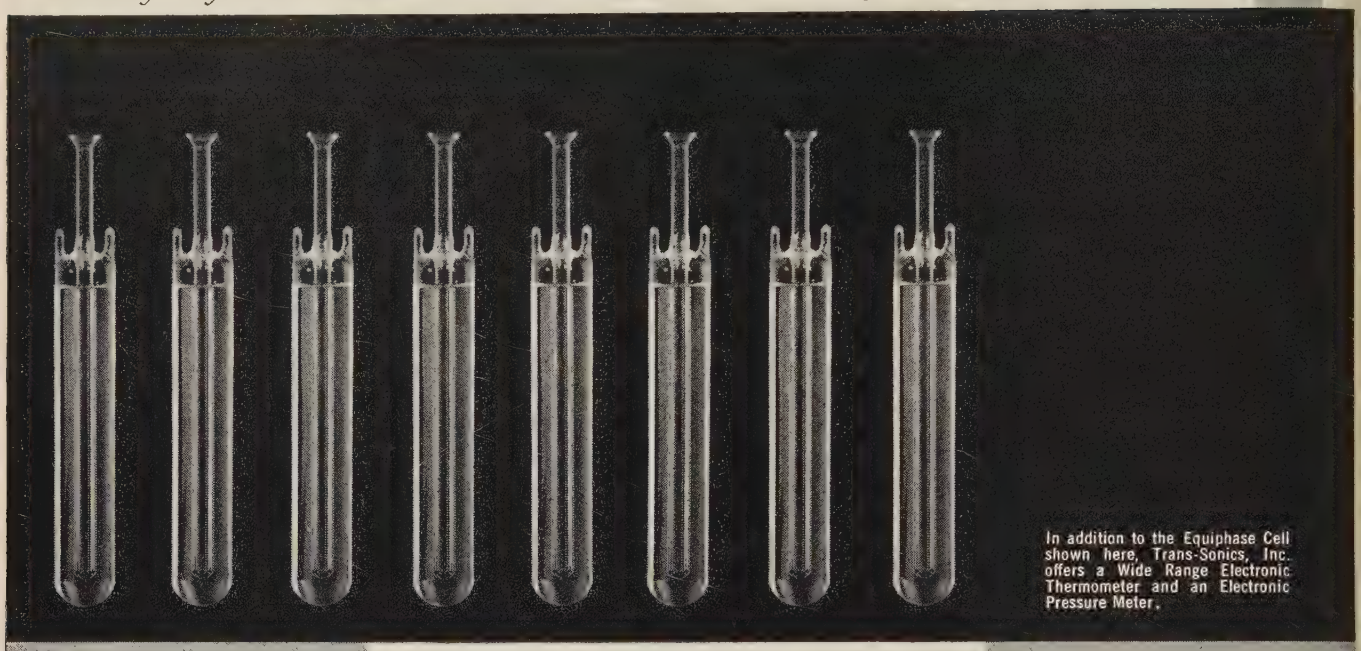

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time schedule puts the manned flight at the end of the year if possible, with an early 1962 date more likely. The American astronaut will make three circuits of the earth before landing. A second attempt to send an unmanned Mercury on a one-orbit trip was expected before the end of August. The first shot, last April, failed when the Atlas booster did not go on the proper heading and was destroyed.

A titanium second-stage rocket chamber for Minuteman has been successfully produced and hydrotested by the Lycoming Division of Avco. The unit is believed to be the largest of its type ever made of titanium, which cuts the chamber weight by about one-third compared to steel. The titanium chambers now being produced required considerable modification of welding and machining techniques used for conventional steel chambers.

AUTOMATIC SYSTEM TELEMETERS BLOOD PRESSURE

An automatic system for measuring blood pressure and telemetering the information to earth from an orbiting manned space vehicle has been developed by AiResearch. It records both systolic and diastolic blood pressure and changes the measurements into electrical signals. Developed under a contract with McDonnell Aircraft, Mercury capsule prime, the system will be used on manned Mercury orbital missions to periodically monitor the astronaut's blood-pressure in order to detect any change in his physical condition. The measuring system could also be adapted for ground use where there is a need for continuous blood-pressure recording, such as in post-surgical recovery rooms.

The system consists of the familiar pressure cuff, a sensor and an electronic transducer. The sensor, mounted in the cuff, is placed over an artery. As the cuff is deflated —after inflation with oxygen from a 200-psia tank—the sensor picks up sounds from the circulatory system and feeds them to the transducer as an electric signal. The transducer filters this signal and picks out the parts due to the systolic and diastolic levels. The filtered signal is amplified and either recorded or telemetered to ground.

During launch, the astronaut's blood-pressure will be taken for six minutes. In orbit it will be recorded every 30 min, and also on six occasions over various ground control centers.

Stabilization for work in space

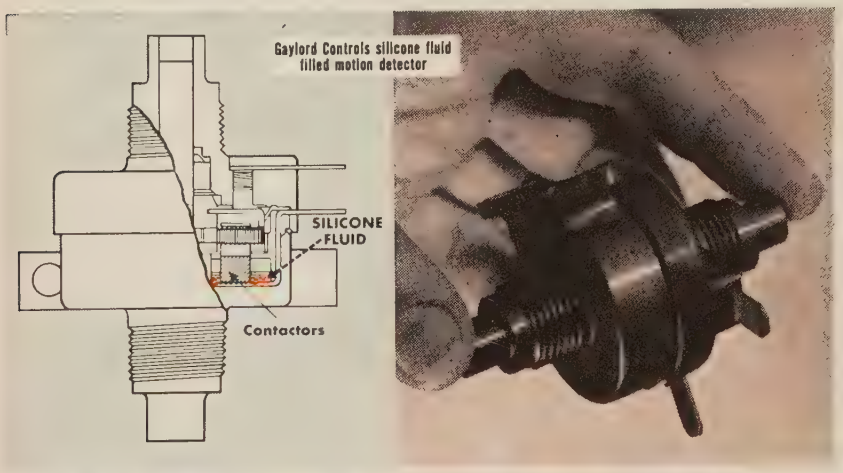
Stabilization and propulsion unit that would allow space mechanics to move about and work outside their spacecraft is being designed by the Astronautics Division of Chance Vought. The unit would counteract reaction forces under weightless conditions, where attempts to use a wrench or screwdriver would rotate the crewman rather than the nut or screw and a welding torch would act as a rocket motor and propel him out into space. The design will be verified by computer studies and a full-scale, non-operating mock-up built.

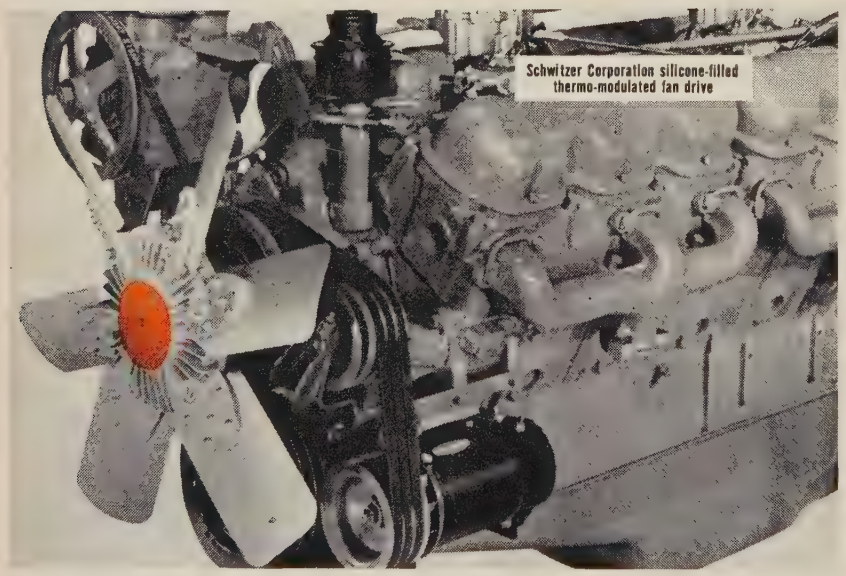
Work on the space unit, called a Space-Man Pak, is being done under an AF contract with the Aeronautical Systems Division. If the studies look good, an operating unit may be built for testing under weightless conditions in ASD aircraft. The unit will be designed for use either with full-pressure suits such as those used by X-15 pilots and Mercury astronauts, or with capsule-type rigid suits with remotely controlled manipulators.

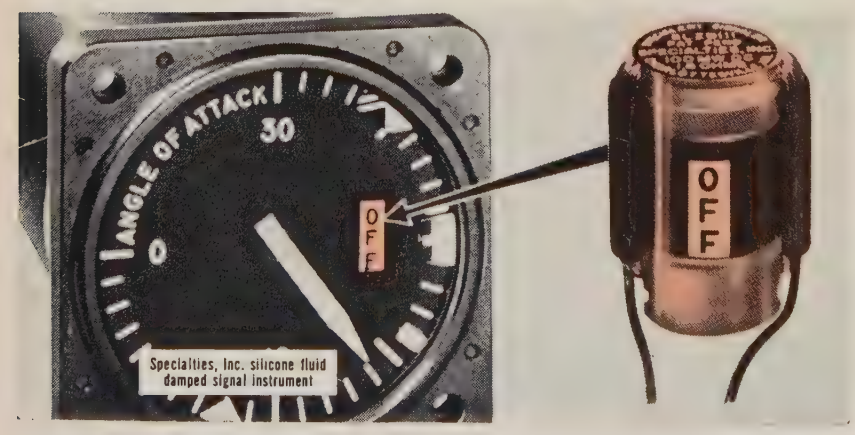
Astronautics engineers are studying both manual and automatic stabilization systems, with torque provided by single-axis gyros, twin gyros, single or twin inertia wheels, and gas jets. Propulsion methods being considered include reaction jets operated by either liquid or solid propellants and a dual-purpose system using the breathing oxygen for propulsion as well. Best methods of activating the controls are also under consideration. In one approach, the crewman would only have to point his finger in the direction in which he wanted to go to have the unit move him that way.

Duplication of the television cameras on Tiros III paid off when the first camera went out after the satellite had been in orbit 12 days. The second was put into full-time operation when the malfunction in the first was detected by the NASA Wallops Island command sta-

Dividend for designers







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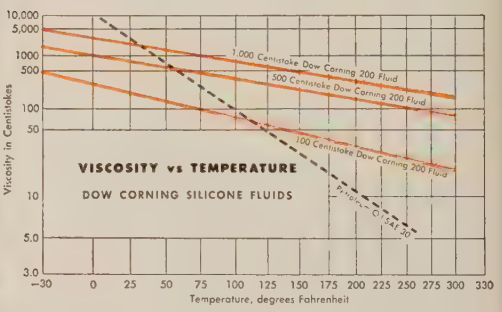

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tion after the 170th orbit. Previous experience with Tiros I and II, which carried one wide- and one narrow-angle camera, had shown that the wide-angle photographs were more valuable, so both cameras on the third satellite were of the wide-angle type.
Until its failure, the first camera had taken 2020 cloud-cover photographs of excellent quality. Number two is also producing good results. The heat budget measurement experiments, to check on the amount of solar radiation reflected by the earth's surface and atmosphere, continue to operate satisfactorily.

F-1 ROCKET ENGINE HITS RECORD THRUST

Rocketdyne's F-1 rocket engine, with a rated thrust of 1.5 million lb, has begun a series of static firings at Edwards Rocket Test Center. The tests are being conducted by Rocketdyne for NASA's Marshall Space Flight Center.

The complete F-1 reached a thrust of over one million lb in the first firings of the series. A gradual build-up will be made until the rated thrust and duration of 2.5 min is achieved. A record thrust of 1.64 million lb has been reached with the thrust chamber of the F-1, and one million lb or more has been registered more than 140 times.

The lox-kerosene engine is slated for the Saturn and Nova launch vehicle programs, for delivery to NASA early in 1963.

Shock-wave tube has 50,000-lb blast

A shock-wave tube with an initial blast equivalent to a 50,000-lb-thrust booster's has been built at Cal Tech. The tube, 80 ft by 17 in. dia, is designed to study the behavior of shock waves in gas densities equivalent to 60-70-mi-high atmospheric pressures. The waves generated in the cannon-like tube travel at up to Mach 8.

Construction of the tube and research to be conducted with it were financed by NASA. The research is concerned with the basic fluid mechanics of rarified gas flows, particularly at high energies, according to Prof. Hans W. Liepmann, professor of aeronautics in charge of the work. Information gained will be used to solve aerodynamic design problems in missile and space technology, such as the design of foils or fins for very high altitude vehicles, design of drag brakes for re-entry of vehicles from space, and cooling of vehicle surfaces at very high speeds.

The tube consists of seven sections of stainless-steel tubing joined with hermetic seals and closed at each end with an inch-thick steel plate. Tube walls are ½ in. thick and have a mirror-finish inside. The tube has two parts, the driver, which constitutes the first 12 ft, and the test section. Driver and test section are separated by a thin aluminum diaphragm.

To use the tube, a differential pressure is established by first pumping out the test to about 10^{-4} mm Hg and then filling the driver with an inert gas under pressure. The diaphragm bulges into the test section until it touches a pair of concave crossed knife-edges and is instantly quartered, releasing the high-pressure gas. This creates a powerful shock wave that traverses the 68-ft test section in one-hundredth of a second.

Twelve thin-film heat transfer gages at intervals along the test section wall measure the wave's velocity; the measurements are automatically recorded. Additional instrumentation will be added later to obtain a more detailed picture of the fast-moving wave.

One aspect of the second manned Mercury suborbital flight remains a mystery. Liberty Bell 7's escape hatch blew off before the rescue helicopter had hooked on to the capsule to stabilize it in an upright position and prevent the doorway from being submerged. Captain Virgil I. Grissom said that he had taken the preliminary steps to firing the explosive train for jettisoning the cover, but had not pushed the actuating plunger. Since the capsule sank in 2800 fathoms, it is not available for examination to see if there was any malfunction in the system.
Although the helicopter managed to hook onto the already swamped capsule before it sank, the weight of the capsule with the water it had shipped was just about the load limit of the copter. The pilot got a warning light that his engine was overheating, and was forced to cut Liberty Bell loose.

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When it comes to High Voltage power packages—boosting power or shrinking size or both together—AMP's Capitron Division is completely equipped to tackle your toughest design and production problem. It has skilled personnel and research facilities—has the exclusive AMPLI-FILM dielectric for tremendous power in smaller packages—has, too, extensive production facilities to give you High Volume and complete quality control.

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MINUTEMAN HITS TARGET AREA 5000 MILES AWAY

The third full-scale test of the Minuteman was a success with the missile going down range about 5000 mi to the target area. A malfunction in the guidance system had required the destruction of the missile on its second firing in May, after a complete success on its initial flight. All three of the tests so far have been from the conventional above-ground launching pad. Testing is now due to start from an underground silo, simulating operational conditions for the solid-fuel missile.

Astronomers protest Project Westford

The Air Force's Project Westford, formerly known as Project Needles, has raised an international storm. The project calls for shooting a cloud of inch-long wire threads into orbit to see if they can be used to form a passive radio reflector. If the first test were successful, the Air Force hoped to make a 2,000-mi-high belt of the needles around the earth.

Radio and conventional astronomers from all parts of the world are protesting the plan, complaining that it will interfere with their observations.

A special committee of the National Academy of Science decided that the preliminary experiment wouldn't do any harm, but the matter is being given further study by the National Space Council.

---

50 prospective astronauts have been selected by the Air Force for future military man-in-space missions, such as Dyna-Soar flights. The space pilots were given about the same tests as were the Mercury astronauts, including rigorous medical examinations, and a variety of stress tests in heat and pressure chambers and centrifuges. Actual training for Dyna-Soar flights has not yet begun, but AF thinks it will have to start soon to have qualified men available for the first manned suborbital flights in the glide-boost vehicle, scheduled for '63-'64.

CHANGES IN SPECS FOR APOLLO BYPASS SATURN C-2 CONFIGURATION

Changes in specifications for Apollo will probably mean that the Saturn C-2 configuration will be skipped and development of the C-3 will be pushed instead. Earlier specs called for a 15,000-lb weight for a circumlunar trip by the three-man spacecraft.

All the design studies submitted to NASA have exceeded this; the figure is now expected to run from 20,000 to 25,000 lb.

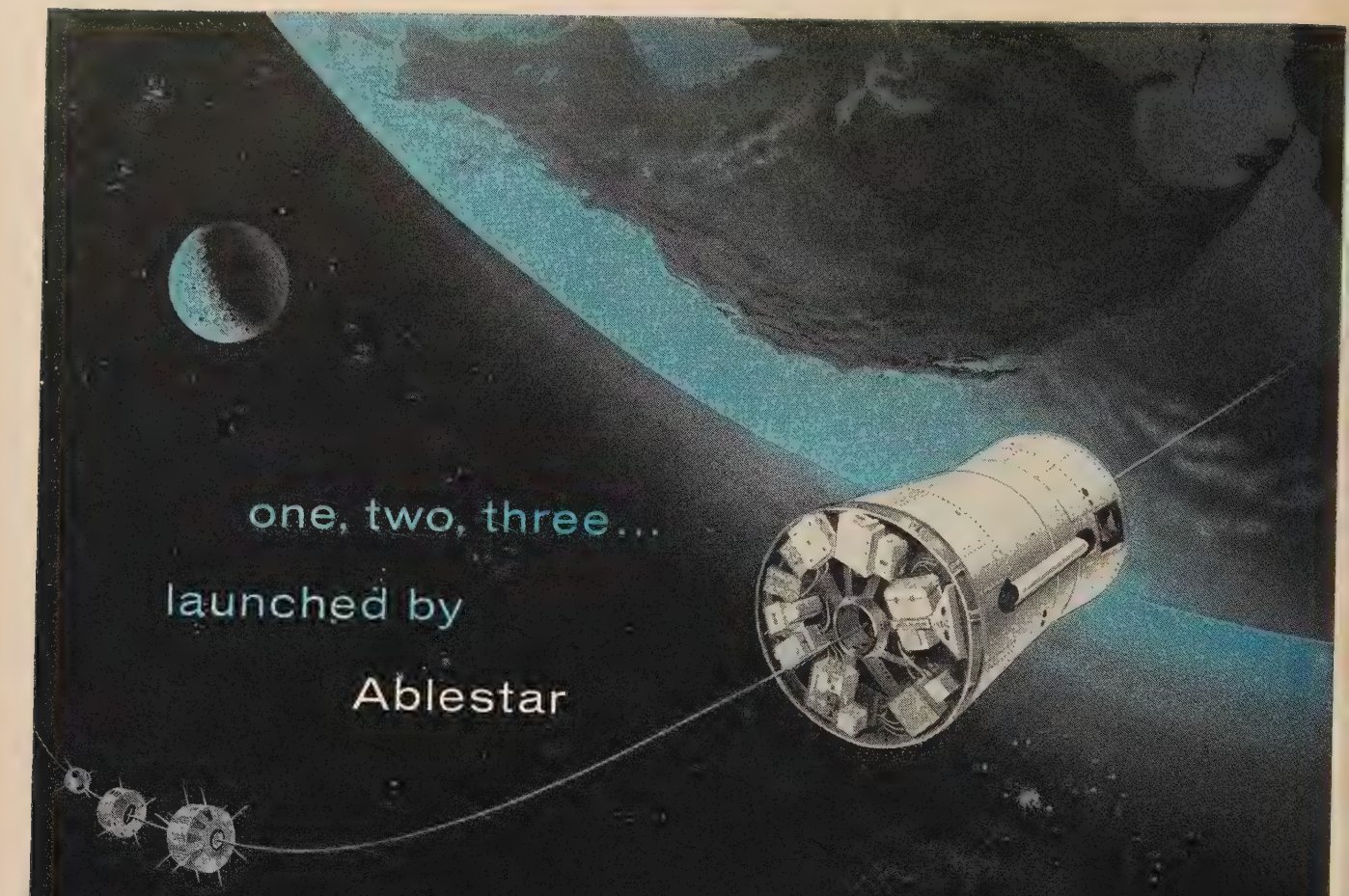
Present layout of the C-3 booster calls for two Rocketdyne F-1 engines with a total thrust of 3,000,000 lb. With different assemblies of upper stages, the Saturn C-3 could put almost 50 tons into an orbit around the earth, send Apollo around the moon, or send a 12-ton payload on a one-way trip to the moon.

System details

Details of the system are: weight, 1300 lb; power, 13 kwe; temperatures, fuel 2190 deg C, cathode 2030 deg C, reflector surface, 1020 deg C; specific weight, 100 ln/kwe. Final development goals are, respectively, 1300, 70 (kwe), 2430, 2230, 1550, 19. The dimensions are: 36 ft in length, and 13 ft in diameter.

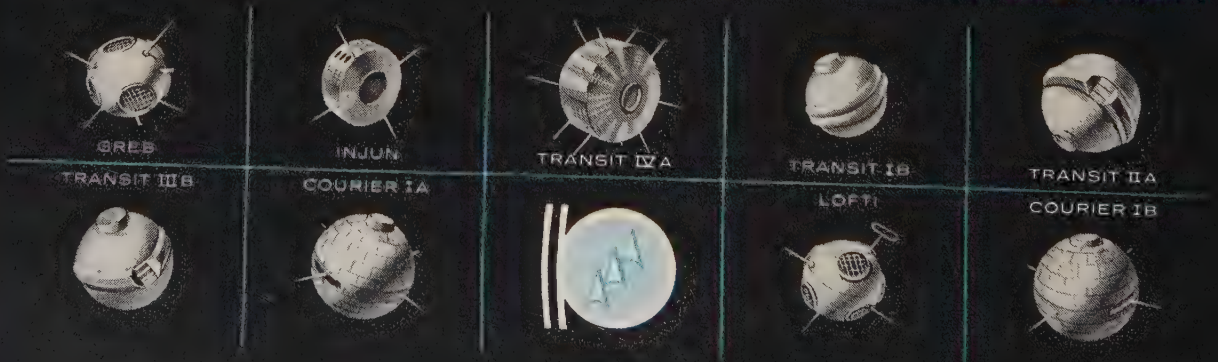
Refractory metals, such as tungsten, tantalum, columbium and molybdenum, would be used. Fuel material would be a uranium carbide-zirconium carbide solid solution. Insulars and vacuum seals would be special high-strength alumina.

Echo I, sent into orbit a year ago with a predicted life-span of only a few weeks, is now expected to stay in orbit for several more years. All the gas with which it was filled must



▸▸ The reliable Ablestar space vehicle recently added to its roster of accomplishments by lofting the space "triplets" Transit IVA, Injun and Greb into orbit. Satellites boosted by Ablestar now total nine . . . an unmatched record. ▸▸ Controlled from earth, restarted in space, Ablestar blends boldness in concept with simplicity and economy in detail and construction. Ablestar is a product of Space-General Corporation, America's uniquely capable source for complete space systems.

▸▸ Other advanced launching vehicles, commercial and navigational satellites, lunar landing systems, space-based weapon systems and nuclear-powered space vehicles are among new accomplishments-in-the-making at Space-General. ▸▸ These programs now offer opportunities for scientists and engineers. Those capable of bringing high levels of skill and energy will be considered without regard to race, creed or national origin. We invite you to contact Pierre Brown, 777 Flower Street, Glendale, California.



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have leaked out by now through holes made by micrometeorites in its thin skin, but there are no forces in space to collapse it. The 100-ft balloon is now in an almost perfectly elliptical orbit. Solar pressure is estimated to be about one housefly-power, and even this doesn't affect Echo's shape, because it is in constant rotation.

PROJECT STAR'S FAST-SPECTRUM REACTOR CONVERTS NUCLEAR HEAT TO ELECTRICITY

Current status of Project Star (*S*pace *T*hermionic *A*uxiliary *R*eactor) was disclosed recently by General Electric Atomic Products Div., Palo Alto, Calif. Star's powerplant is a compact nuclear electric power supply. It uses a fast-spectrum cylindrical reactor to convert heat generated by nuclear fission directly to electricity by cesium-plasma thermionic converters attached to surface of reactor. Unconverted heat is rejected by radiation directly to free space from the converter anodes. These form the outer reactor surface and also serve as radial neutron reflectors.

Reactor itself is a hollow cylinder composed of a series of identical segmented rings. Each ring is made up of individual fuel cell elements consisting of reactor fuel and a thermionic converter. All thermionic converter-fuel cells comprising a ring are electrically connected in parallel; segmented reactor rings are series-connected and supported by bus bars which run the length of the reactor.

Movement of an end reflector starts the reactor and shuts it down. Continuous operation of 10-20,000 hr appears attainable, GE states.

Cargo system ups DC-7CF capacity

Airpak palletized preloading cargo system for DC-7CF Douglas cargo planes has been demonstrated by Douglas and Pan American World Airways. Cargo floors of the PAWA planes were outfitted with a roller and ball-bearing decking.

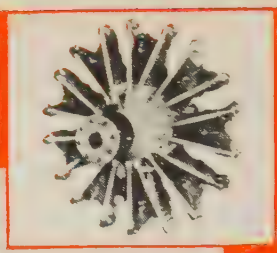
The preloaded pallets are forklifted to airplane deck height, pushed inside by means of a roller transfer platform, then moved back into position in the cabin. Quick snap locks and guides secure the pallets inside the plane.

The new cargo system will up maximum payload capacity of 7C from present 31,700 lb to at least 36,000 lb and possibly more; it adds a weight of 2000 lb. Modifications will beef up structure and take out unneeded weight for a net gain of over 4000 lb while absorbing the cargo-system weight at same time, it was stated. Carrying maximum payload with the new setup, of course, will decrease range somewhat. Modified craft will carry 36,000 lb 2300 nm against zero wind. PAWA cargo fleet using this system will include 10 DC-7Cs already modified for cargo and 1-3 more passenger planes.

Tenfold increase in oxidation resistance for areas within tungsten-columbium-tantalum systems can be achieved, screening tests at Union Carbide Metals Co. indicate. These results would be at a temperature of 2190 deg F. J. L. Wilson and C. R. McKinsey report that complete data on fabricability and tensile properties are not yet available but "there is every indication that certain alloys within this ternary system offer considerable promise for elevated-temperature structural applications." Wilson and McKinsey made studies to find whether solid solution of the three metals would provide a better combination of properties than the pure metals for elevated temperature uses.

Target missile tested successfully

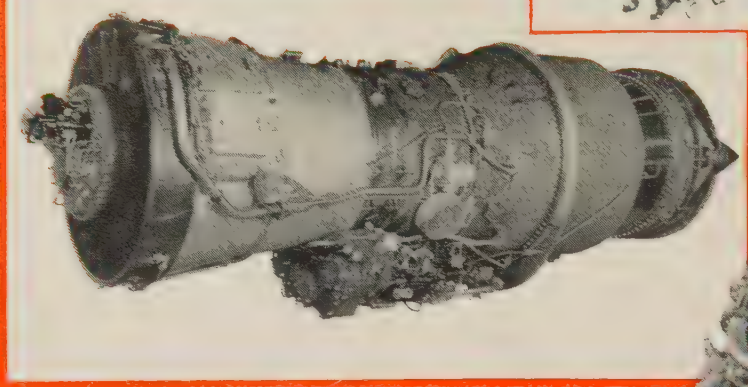
Redhead-Roadrunner supersonic target missile, built by North American, completed successful firing tests at Army's White Sands Missile Range, N. Mex. The ramjet-powered vehicle was launched from a standard launcher under power of its 6000-lb-thrust booster. It is said to be the only training missile capable of flying missions at altitudes from 300 to 60,000 ft and speeds from subsonic to Mach 2. The missile is one foot in diameter and 19 ft long. Span of triangular wings is six feet.

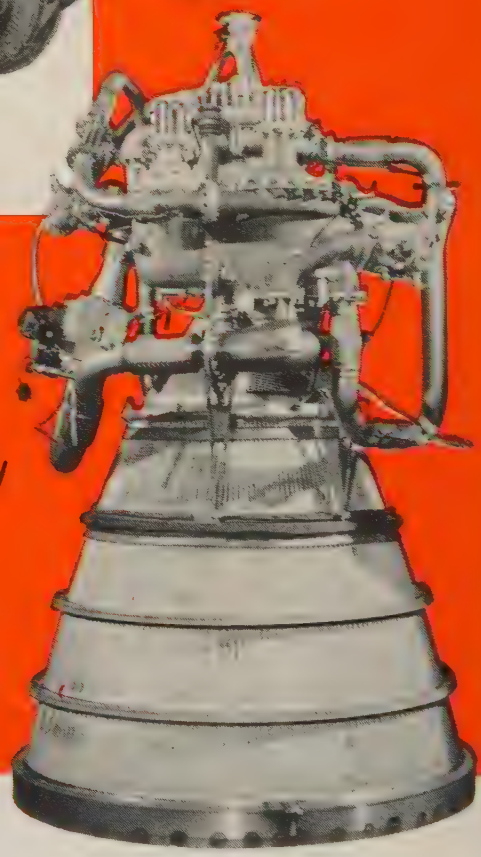


Wasp Jr.

J-57

LR-115





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Progress in engine design and performance represented by these three engines obviously required matching improvements in all component categories as well. The Elastic Stop® nuts that were standard parts for the early Wasps were constantly supplemented by new designs equal to the special temperature, load and environmental conditions demanded by this power-plant evolution.

The Elastic Stop nuts illustrated here are specified in several sizes for the assembly of pipe flanges, brackets, engine mounts and pump flanges of the LR-115. They are typical of the fasteners designed for compatibility with the liquid hydrogen environment and unusual very high—very low temperature demands of this rocket engine.

ESNA has consistently accepted a full share of the responsibility to investigate and propose solutions for fastening problems created by the changing technology of the engine industry. These efforts have helped to establish and maintain ESNA's position as the foremost supplier of self-locking nuts specifically designed and produced to the unique reliability requirements of the aircraft engine industry. Write ESNA for a copy of High Temperature Design Catalog No. 5918.

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INDUSTRY BRIEFING

Stein

Analyzing self-adapting communication systems

METHODS of improving communications by adapting transmitters and receivers to changes in the transmission channel, such as signal fading and varying noise levels, are being studied at Sylvania's Applied Research Lab, Waltham, Mass.

Directing the $81,000 Air Force project is Dr. Seymour Stein of the Lab's communications research department.

"Immediate critical area in these studies," explains Dr. Stein, "is a better understanding of performance to be expected from practical feedback circuits, including errors due to noise and fading on the feedback loop. Certain critical types of errors can occur, which we have termed 'message displacements', which may be especially severe in digital data or cryptographic uses. Beyond this lie problems of synchronization, equipment economics, and especially the storage which may be needed in high data rate systems."

"Our lab," Dr. Stein told SPACE/AERONAUTICS, "is looking for more qualified senior personnel to work in this area. We expect development work in the near future to follow up on successful results in our current theoretical studies. This work would include design of breadboard equipment, and might have to include development of some new types of lab simulation equipment for extensive testing."

Schultz

". . . a need for physicists and chemists."

HEADING North American Aviation's new Electro-Physical Lab is Dr. Robert D. Shultz. The lab is the NAA Space & Information Division's basic research unit, and will investigate direct conversion of heat to electricity, charged colloid propulsion, and organic semi-conduction.

"One of our objectives," Dr. Schultz told SPACE/AERONAUTICS, "is to integrate the scientific disciplines of physics and chemistry in order to solve some of the problems which will be met in space flight."

Final staffing of the lab isn't fixed yet. "However, a need exists for solid-state physicists, chemical physicists, physical organic chemists, and organic chemists with experience in the synthesis of polymers and/or dyes," Schultz said.

At present he plans to use the facilities of the Space & Information Systems Division in Downey, Calif.

The lab already is working on a thermionic device which Schultz feels may represent a significant advance in direct energy conversion technology. Known as an auxiliary discharge rare gas plasma diode, it may be able to convert heat directly into electricity, with about 14 per cent efficiency, at a cathode temperature of only 1300 deg K—at least 500 deg K lower than that needed by cesium plasma converters.

Studies of electrical propulsion by charged colloidal-sized liquid droplets and development of semiconductors are also under way.

Dr. Schultz earned his bachelor's degree in chemical engineering from CCNY in New York, and his doctorate in physical chemistry from NYU. Before joining NAA, he had been with Aerojet General and Brookhaven National Laboratory.

Liepmann—New shock tube packs much greater wallop

A UNIQUE shock tube is being calibrated at California Institute of Technology, Pasadena, Calif. It will be used to study the behavior of shock waves in gas densities equivalent to pressures at 60-70 miles up.

"Progress in the missile and satellite fields calls for more information on the flow of very hot and very rarified gases," says Dr. Hans W. Liepmann, CalTech's professor of aeronautics. In this area," he adds, "much remains to be done and should be done so that design information about high-altitude vehicles can be based on a broad and solid foundation."

This information will solve many aerodynamic problems in space and missile technology, Dr. Liepmann explains. Typical problems are the design of foils or fins for very high altitude vehicles, design of drag brakes for re-entry of vehicles from space, and cooling of vehicle surfaces at very high speeds.

The cannon-like shock tube is in seven sealed sections of stainless steel with walls one-half inch thick. It fires an initial blast equal to that of an intermediate ballistic missile with 50,000 lb thrust. The shock wave, confined in the big tube, packs a much greater wallop than does the familiar sonic boom made by jets. It travels faster, too, up to Mach 8.

Construction and research are supported by NASA.

Rolsten

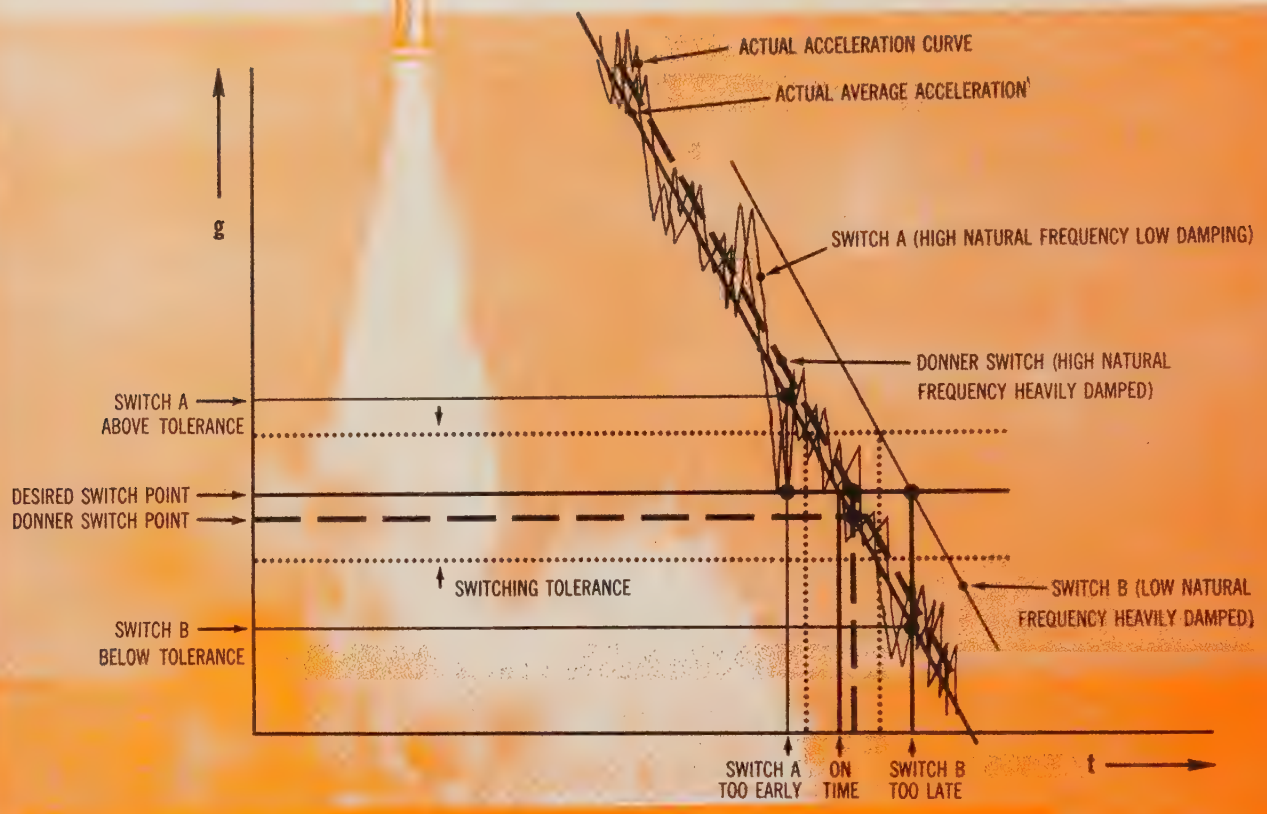
Setting up design concepts for "meteoroid bumpers"

HOW THICK should a space vehicle's meteoroid bumper be, and how far should it be from the main structure?

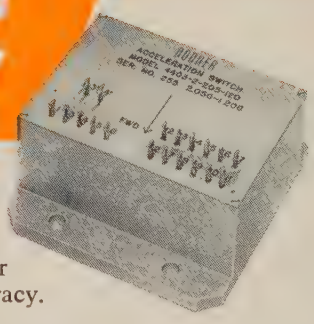
Dr. Robert F. Rolsten, Convair Engineering Materials Technical Group, is going to find out. He is the project leader of a one-year, $54,000 NASA contract for theoretical research on meteoroid impact.

Says Rolsten: "We can't yet duplicate in the lab the 30,000- to 300,000-fps impact velocities that may be met in space." So his group will use shaped explosive charges to accelerate small projectiles up to 15,000-20,000 fps. Targets will be such materials as aluminum alloy, type 6061-T6, copper, titanium, and magnesium. Advanced acceleration techniques will get

There's only one reason to specify Donner acceleration switches



..BECAUSE THEY UNDERSTAND THE MEANING OF ACCURACY



It's dynamic accuracy that counts. In truth, several firms make precision acceleration switches. But accuracy, like reliability, is a term with shades of definition. Some switches are accurate in the lab or on the test bench. That is, they provide *static* accuracy. Donner acceleration switches give you accuracy where it counts, on the operational missile. They are *dynamically* accurate.

Look at the graph above. Under static conditions, switch "A" with a better switching response, might be desirable. But suppose the missile were experiencing a 10 g vibration of a high frequency nature and proper thrust cutoff depended on detecting a 2 g switch point. Switch "B" would eliminate the problems of early switching, but introduce intolerable phase shift which in turn would make the switch "see" the event after it actually occurred. In other words, under the dynamic conditions of missile and aircraft flight, it is absolutely necessary to know when an event occurred rather than precisely where it occurred. Frequency response becomes a more important consideration than switch accuracy.

Heavily damped, with a high natural frequency, Donner acceleration switches have low phase shift providing the transient response necessary to follow rocket engine operation and perform their task with meaningful accuracy.

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velocities up to 150,000 fps. Convair has developed a unique self-timing linear accelerator for this purpose.

Dr. Rolsten, who earned his Ph.D in chemistry at Ohio State in '55, has been a research chemist for Battelle, du Pont, and U. S. Borax Research Corp. He joined Convair (San Diego) in 1960.

Berger

Fuel cell research pays off

SELF-SPONSORED research by Ionics, Inc., Cambridge, Mass., paid off in the form of a $49,381 USAF contract. Ionics had been developing a lightweight fuel cell for generating electric power in satellites and space vehicles when the Electronic Systems Division of AF Systems Command got interested. Work now is sponsored by the Office of Aerospace Research.

Dr. Carl Berger, assistant director of research for Ionics, is in charge of the work under Wayne A. McRae, vice president of research. Project leader is Dr. Robert M. Lurie.

The Ionics Fuelox cell, says Dr. Berger, operates on hydrogen gas and a solution of common chemicals, bromine and water. It has shown unusual capabilities. The cell will be useful for powering instruments, life-support equipment, communications facilities, lighting and other apparatus needed for manned satellites and space vehicles. The cell can be recharged by solar cells, and can also be used to store electric energy from other sources, Dr. Berger says.

A key part of the cell design, McRae points out, is the special plastic ion exchange membranes developed by Ionics. These make possible the cell's superior performance, he says.

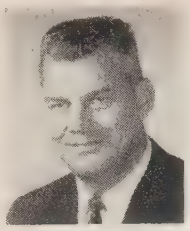
Dr. Berger worked in metal disposition, plastic technology and photochemistry before joining Ionics in June 1959. Since then, he has been working on fuel-cell development and electrodialysis cells, particularly as related to new electrodes, catalysts and ion membranes for fuel cell systems. He has a BS from CCNY in New York, an MS from Fordham University in biochemistry, and a Ph.D in physical chemistry from the University of Kentucky.

Warning systems for astronauts and ground controllers

REQUIREMENTS for a warning system that can detect or predict emergencies in a spacecraft and react in thousandths of a second are being studied by Chance Vought's Astronautics Division, Dallas, Texas.

The $76,000 USAF program calls for a system which will warn the astronaut or ground controller for appropriate action or—if need be—start escape automatically.

"We see a system which will minimize man's reaction time," said R. J. Garnett, project engineer on the program. "For warning devices we shall study use of lights of various intensities and colors, auditory signals such as buzzers, bells, tone signals and voice recordings, mild electrical shock, pressure application control, shaking devices and other methods, singly and in combination."



Hartings

"Cryogenic test facility is a necessary step."

ONE OF the most versatile cryogenic facilities in the U.S. has started operating in Columbus, Ohio. It is being used by Janitrol Aircraft Division (Midland-Ross Corp.) to test hardware components and systems operating on liquid hydrogen, nitrogen and other cryogenic fluids.

Edward M. Hartings, Laboratory & Approvals Engineer, is directly responsible for operation of the facility. A graduate of Ohio State in industrial engineering, he's been with Janitrol since '46. He is in charge of all engineering test work, including the testing of cryogenic hardware designed by the company.

"Janitrol considers this a necessary step in developing new cryogenic valves and heat exchangers as well as other related items," Hartings told SPACE/AERONAUTICS.

"We expect that additional personnel will be required as the work load builds up," Hartings says. However, he went on, "Janitrol has enough engineering and technical support people with experience in cryogenic, missile, and space fields to operate the new facility for the present."

The group will study problems in the control of flow and pressure of liquid hydrogen and other cryogens under vacuum conditions.

Brown

To produce training equipment for Sergeant missile

AIRCRAFT ARMAMENTS, Inc., won a $2.5 million contract recently to build crew training devices for Army's Sergeant ballistic missile. The Cockeysville, Md., firm has named Frederick W. Brown to be project manager for the program. AAI has been working on the prototype equipment for the past 18 months under a Navy R&D contract.

"Each of the missile trainers," explained Brown, "will consist of a training missile, two instructors' consoles, and an interconnecting system." Field crews will be able to make practice runs in launching Sergeant from preflight checkout at the maintenance test station through checkout in the firing area.

Brown, who received his BE (Mechanical) at Johns Hopkins in '49, has been system design and analysis and project manager in the Electro-Mechanical department at AAI since 1956. Earlier he had worked at Friez Instrument Division, Bendix, as project engineer.

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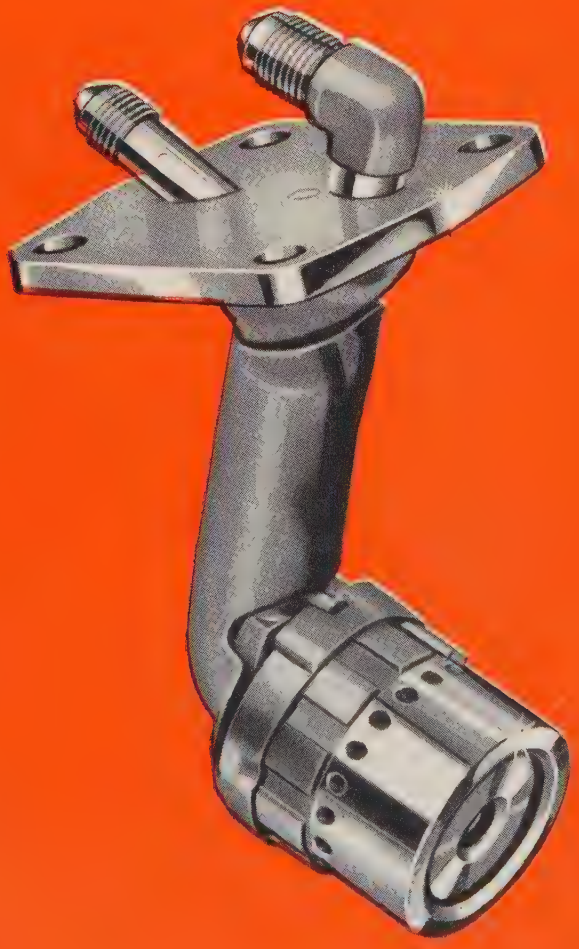

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CALENDAR

SEPTEMBER

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Sept. 4-14 Eighth Anglo-American Aeronautical Conference. Royal Aeronautical Society and Institute of the Aerospace Sciences, London, England

Sept. 20-24 National Convention and Aerospace Panorama, Air Force Assn., Philadelphia, Pa.

Oct. 2-7 12th International Astronomical Congress, Washington, D. C.

Oct. 9-13 National Aerospace Engineering & Manufacturing Meeting, Society of Automotive Engineers, Ambassador Hotel, Los Angeles, Calif.

Oct. 9-15 American Rocket Society's 16th Annual Meeting & Space Flight Report to the Nation, Coliseum, New York, N. Y.

Oct. 11 Fall Symposium of the Institute of Printed Circuits, Sheraton-Chicago Hotel, Chicago, Ill.

Oct. 14-22 Federation Aeronautique Internationale 1961 General Conference, Hotel Quintandinha, Rio de Janeiro, Brazil

Oct. 24-26 International Symposium on Aerospace Nuclear Propulsion, Institute of Radio Engineers, Riviera Hotel, Las Vegas, Nev.

Oct. 24-25 Electronics Division of the American Society for Quality Control (ASQC) Sheraton Hotel, Philadelphia, Pa.

Oct. 26-27 Third Annual Symposium on High-Speed Testing, Hotel Somerset, Boston, Mass.

Nov. 1-3 International Conference on High Magnetic Fields, Cambridge Institute of Technology, Cambridge, Mass.

Nov. 9-10 11th National Conference, Aircraft and Missiles Division of American Society for Quality Control, Ambassador Hotel, Los Angeles, Calif.

Nov. 14 Electronic Systems Reliability Symposium, Kansas City, Missouri

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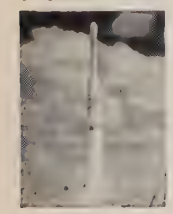

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DO WE STILL NEED

by **Randolph Hawthorne,** Editor

ARE MANNED BOMBERS vital to our strategic arsenal? The argument goes on almost incessantly between the Air Force's experts on military requirements and the experts of the Office of the Secretary of Defense (OSD).

The Air Force is almost desperately convinced that the manned bomber is a vital part of our strategic arsenal, now and in the foreseeable future. The OSD people are just as sure that the ICBM alone provides an adequate deterrent to war and an effective strategic weapon. They agree that manned bombers will be needed, but only until about the end of the sixties or the early seventies. The Air Force, too, wants ICBMs, but in addition it contends that the need for manned bombers extends into the indefinite future.

Complicating all points at issue are the requirements of "cold" and "hot" war: A weapon system must act both as a deterrent to aggression and as a weapon that, if war does occur, can destroy its target. Some of the major disputes between USAF and OSD therefore have centered on:

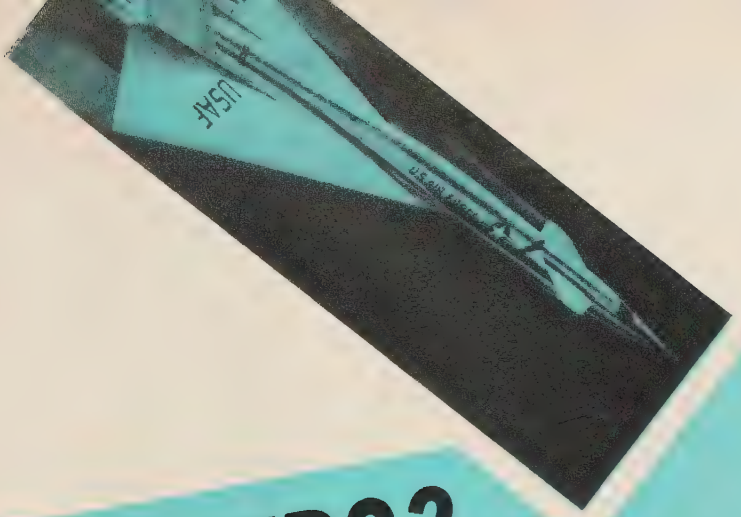
- the "inflexibility" of an ICBM force;
- the need for human intelligence and judgment in a nuclear war;
- the cost to the enemy of meeting the penetration threat posed by B-70-type bombers;
- the deterrent value of ICBM's vs manned bombers;
- the B-70's ability to penetrate enemy defenses;
- the effects of disarmament agreements outlawing atomic weapons and/or missiles.

Not one of these points is open to a clearcut, scientific solution. As Dr. Herbert York said of the B-70 before the House Appropriations subcommittee: "The big question is not really a scientific one, but a military operational question." If the former director of DOD research and engineering is right and the B-70 could be built to Air Force specifications and requirements, then the "eye" of the B-70 "storm" and of the manned bomber dispute in general is centered over the area of military requirements.

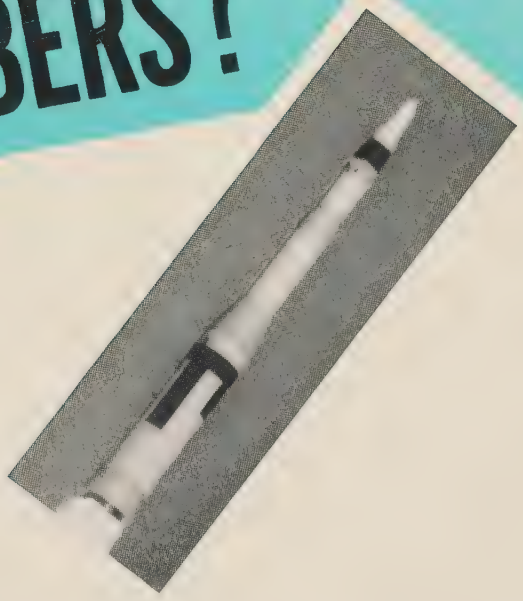
Opinion divides somewhat fuzzily over the relative flexibility of ICBMs and manned bombers. The Air Force argument runs this way:

Manned bombers are needed because missiles are exceedingly inflexible. If you are limited to a system of offense that has only two modes—"go" and "no go"—you have greatly reduced your strategic choice. It will be inadequate to meet some of the threats which may confront us. Strategic bombers, on the other hand, have wide application across the entire spectrum of conflict—from cold war through limited war to all-out nuclear war.

In a cold war, a bomber force can demonstrate its readiness and shift its deployment visibly with im-



MANNED BOMBERS?



portant political and psychological effects. In limited war, it can be used for delivering TNT (as in the Korean war).

In all-out nuclear war, manned bombers can be the winning weapon. They can strike any target that a missile can strike and do a lot more:

- They can strike with greater assurance of accuracy than an ICBM.
- They can strike with weapons of all sizes, including warheads too small or too large for efficient use in an ICBM.
- They can strike targets whose locations are not definitely known and which therefore cannot profitably be assigned to missiles.
- They can be recalled (whereas missiles can't).
- They can assess and report the results of their own missions as well as those of other strikes. Therefore they need not hit targets already destroyed but can proceed to other targets, and they can check on targets that may have survived the first ICBM attack and strike those. The ICBM, on the other hand, can strike only a single, pre-programed target.

IN BRIEF

To line up the pros and cons about the B-70, Space/Aeronautics interviewed the men who are actually fighting the battle in the Air Force and the Office of the Secretary of Defense and combed through volumes of Congressional testimony. The result is a series of questions, ranging from such relatively "simple" ones as "Could the B-70 get through Russia's defenses?" to such widely speculative ones as "What happens if atomic weapons are outlawed?" But the biggest (and still unresolved) question is: Who has the right answers?

The Questions in the B-70 Controversy

- How flexible is an ICBM force?
- How much human judgment is needed in a nuclear war?
- Is an ICBM force another Maginot Line?
- What does the defense against Mach 3 bombers cost?
- How much does it take to scare the enemy?
- Can the B-70 get through the enemy's defenses?
- What happens if atomic weapons are outlawed?

OSD admits that the manned bomber is a little more flexible than an ICBM—but not very much. The B-70, for example, they say, cannot bomb targets of opportunity (although Air Force says it can) at the speeds and altitudes at which it will fly.

The B-70 can make small corrections over enemy territory, OSD agrees, and it can do a certain amount of search and find something within a few miles if a target isn't exactly where Intelligence said it would be. But the B-70 has been aptly called a manned missile, says OSD. The man in the B-70 does almost the same as would a man in a missile, which really is very little except to make sure everything is going as planned.

Can't recall bomb either

ICBMs cannot be recalled, OSD experts further agree. But missiles don't have to be launched until the moment you decide it is necessary. And once a bomb is dropped or a missile fired from a bomber, OSD points out, they can't be recalled either.

Moreover, OSD claims, by putting bombers in the air, you are really doing no more than getting them ready to strike and making them safe from attack without committing yourself to using them. The same is true already of the Polaris, OSD points out, safely hidden under the ocean. It will be true also of land-based ICBMs—once we have enough of them in hardened bases.

OSD firmly believes that ICBMs can be developed to the point where they are so "adequately" reliable that no manned bombers will be needed to knock out targets not taken care of by ICBMs. This reliability, OSD declares, can be achieved within the period when the B-52H armed with Skybolts must be phased out.

Lower-echelon OSD experts are so sure of this future ICBM reliability that they would rule out the B-70 even as an R&D program, if it weren't for the row that would stir up in Congress. As it is, because the cost of development "is sufficiently small compared to the cost of procurement of any major strategic system," OSD supports the present B-70 program "to maintain the option for having a system of this kind."

York put the OSD position quite bluntly when he told the House Appropriations subcommittee that "there is no firm requirement for a B-70 aircraft at this time." The Air Force, of course, couldn't disagree more.

Another clue to OSD thinking is the view, expressed by York, that "the primary purpose of any strategic weapon is deterrence . . . " and that "we can build a quite adequate deterrent force around missiles" in the period in which the B-70 can be developed.

This would seem to imply that York thinks that war can be prevented if the aggressor knows you have strategic weapons powerful enough to wipe him out, and that the ICBM will be such a weapon. Therefore, why spend money on manned bombers?

The Air Force experts object by saying that the primary purpose of a strategic weapon is to destroy its target. According to the degree it can achieve this objective, it will also act as a deterrent. Furthermore, argues the Air Force, putting all your defense hopes on the ICBM amounts to a Maginot Line attitude.

We must have a variety of responses to attack, the Air Force declares, because the enemy can mount an infinite variety of attacks.

OSD isn't greatly impressed by Air Force arguments that human judgment would be at a premium in a nuclear war (at least over enemy territory). "Judgment, smudgment!" exclaimed an OSD man with 10 years of SAC experience when questioned on this point. Then, when it came to his own and his colleagues' judgment, he formulated a rather novel doctrine of military planning: "The Air Force should tell us what the military requirement is, not what specific hardware they want."

The psychological effect of the ICBMs as a static weapon was perhaps best described by former Air Force chief of staff General Thomas D. White. Without the B-70, he told the House Appropriations subcommittee, "this country would have to depend for its survival on missiles for nearly 100 per cent of its offensive capability."

ICBMs will have to be manned hour after hour, year after year, by people ready to fire them on 15 minutes' notice and with nothing to do but wait, White said. "They are going to be static, be they in the ground, on top of the ground, or under the sea . . . The psychology of [missile personnel] is going to present a whole new aspect to our people. There is nothing dynamic about it.

"And, moreover, I fear that the nation itself will acquire a static psychology in relation to our major weapons in time of general war. It is tantamount to the Maginot Line to an extraordinary degree which could be fatal to this nation. We have had so-called invulnerable weapon systems in the past. The Merrimac was one. I am sure the Great Wall of China was another. The Maginot Line is more recent. There is no such thing as an invulnerable system."

White's point is obviously moot. The most one can say for it is that White is an experienced leader of men and therefore knows about effects on morale. The least one can say is that he is not a professional psychologist, so anyone's guess is as good as his.

There is a sharp difference of opinion between OSD and the Air Force on the need for a strategic weapons "mix" after the B-52 phase-out. If the enemy has to defend himself only against missiles, USAF says, his task is easier and less expensive than if he must defend against both missiles and bombers.

B-70s, Air Force people point out, would force the enemy's anti-bomber defenses into altitudes of 50,000 ft and higher—where he now worries only about ICBMs. They estimate that it would cost the Reds something like $40 billion to defend against even a small number of B-70s. For every dollar that we put into the B-70, an Air Force expert has said, the Reds would have to spend about $13 for defense.

Defense Secretary McNamara rejects these figures. He flatly doesn't believe that "action on the B-70 by itself will lead to direct action by the Soviet Union. There is no cause-and-effect relationship as clear as thirteen dollars being expended because we spent one dollar," he says.

Although the dollar figures offered by the Air Force are questionable as a means of comparison of Soviet and U.S. efforts, it would seem probable that the Reds would have to make some defense against the B-70 threat. In fact, it will be interesting to see whether or not we shall take "direct action" in the face of the *Red* B-70-type threat that may now be developing.

No known defense against ICBMs

The nuclear-tipped ICBM, OSD believes, is a greater war deterrent than the manned bomber. It points out that there is no known defense against the ICBM and little likelihood of any that will be effective in the foreseeable future. (OSD doesn't think the Nike-Zeus will do, even should it pass its Atlas intercept tests next year.)

The Air Force's reply again is based on psychology. A deterrent obviously deters only to the extent that it impresses a would-be aggressor.

How can you, sitting in a hole thousands of miles from the scene, with your finger on the ICBM "go" button, convince the enemy and his people that you are ready to fight to save Berlin, asks the Air Force. All you can do is to say you are ready. But what if talk won't impress the enemy? What if he has to be shown?

You can't show him our ICBMs. But you can show him our bombers. You can send them out to hover outside his territory where they can be seen on his radar scope. He knows you are there. And your friends know you are there when you fly over friendly territory.

OSD people are counting on the awesome threat of the ICBMs to impress the Reds. Apparently they discount the need to make a "show of force."

The B-70's ability to penetrate enemy defenses during its operational life (from late sixties to 1975) is doubted by OSD. Said McNamara: "In the light of the increasing capabilities of ground-to-air missiles, the speed and altitude of the B-70, in itself, would no longer be a very significant advantage."

OSD also claims that the B-70 would have too large a radar cross-section and too strong an infrared signature. It argues that the B-70 wasn't designed to use air-to-surface missiles like the Skybolt, and would have to fly at subsonic speeds in a low altitude attack. Finally, OSD says, the B-70 would be more vulnerable on the ground than hardened missiles and it could not readily be put on airborne alert.

The Air Force flatly disputes all these points:

- With all its countermeasures, with its Mach 3 speed, and with its tactical flexibility, the B-70 could penetrate the Soviet defenses (which right now couldn't stop even a B-52 attack).
- An outgrowth of the Skybolt could be adapted to the B-70, which has structural "hard" points on the wing for that purpose.
- Normally the B-70 would operate at its design altitude and Mach 3 cruise speed. If necessary, it could operate at low altitude and subsonic speed. But this would be an extension of its capabilities, not a limitation.
- The B-70 could get off the ground in five minutes by simultaneous start of its six engines. This would reduce its vulnerability considerably.
- The B-70's intercontinental range could be extended to a global range by refueling from KC-135 tankers. Therefore it could be put on airborne alert.

Argument for manned bombers

A big argument for manned bombers is the possibility of a disarmanent agreement that would eliminate atomic weapons, just as gas was eliminated after World War I. If that happens, the Air Force says, our ICBMs would be almost useless—they might even be outlawed, too. Where would we be then, Air Force asks, if our strategic arsenal contained nothing but ICBMs?

No official OSD answer has been made to that point. One OSD expert has said that he cannot believe our political leaders would ever make such an agreement. However, he had to concede the possibility that they might.

Regardless of which side you take in the controversy, whether we need the B-70 or can phase out manned bombers with the B-52H in the end is a matter of judgment. The question is, whose judgment is the most authoritative?

Should the Air Force be the judge of its special requirements and capabilities? Or the Joint Chiefs of Staff? Or is OSD the best judge?

How the JCS made up their collective mind on the B-70 program throws some light on the nature of their deliberations. Asked by the House Appropriations subcommittee whether the JCS agreed that the B-70 program was a good one, JCS chairman General L. L. Lemnitzer replied: "It was not expressed in those terms. There was a question of what could be bought with the available resources that would produce more defense than putting the money into the B-70."

Faced by the prospect that whatever money went to the B-70 would reduce the "available resources" for his service, each member of the JCS—being also the chief of his own service—was forced to a conservative view of the needs of the Air Force, which competed for those dollars. The JCS decision, therefore, was not based strictly on the merits of the B-70 as a weapon which the Air Force claims is a vital part of the strategic arsenal. Financial considerations, not military judgment of requirements, defeated an expanded B-70 program in the JCS.

The final decision against the expanded B-70 program actually was made by the President, who accepted OSD's judgment over the Air Force's—though it can well be argued that in the area of its own requirements the Air Force should know best what is needed.

Hypersonic fasteners use "exotic" forms and materials

DESPITE THE strong trend toward welding, bonding, and brazing, considerable numbers of mechanical fasteners will still be needed in all future aerospace vehicles. Tomorrow's fasteners, though, will be quite different from the designs we have been used to—at least that's the basic finding of a series of current development programs on advanced fasteners.

Reporting on one of these programs, engineers at Republic Aviation Corp., Farmingdale, N.Y., point out that some of the most stringent environmental requirements of hypersonic fastener design are caused by the extreme variation of thermal effects during a single vehicle mission (*Table I*). A typical hypersonic cruise vehicle, for instance, may have temperature variations of —400 to 500 deg F externally. For a manned orbital vehicle using a cryogenic fuel, the corresponding ranges

Table I: Environmental Extremes for Advanced Vehicles

	Hypersonic Vehicle (1½-Hr Cruise at 100,000 Ft)		Orbital Aircraft (4¼-Hr Mission to 250,000 Ft)	
	Temperature (deg F)	Load Level	Temperature (deg F)	Load Level
Nose	2000-2600	low	2000-5000	low to very low
Wing leading edge	1800-2100		2000-5000	
Control leading edge	1800-2100		2000-4100	
Lower surface	1100-1400		800-2500	
Upper surface	600-800		300-1300	
Control surface	1400-1600	moderate	1000-2800	moderate to very low
Interior structure	—420 to 500	high	—300 to 1800	
Tank structure	—420 to 500	moderate	—400 to 1800	high to very low
Inlet leading edge			1000-3400	low to very low

by Irwin Stambler, Associate Editor

might be —400 to 1800 deg F and ambient to 4000 deg F. To maintain structural integrity at the upper limits of these ranges, Republic states, we will need fasteners made of refractory metals, and these will then require coatings to protect them from oxidation.

Of course, though the new fasteners basically will be designed for high-temperature service, they will still have to function at the lower temperatures, too. They will, in fact, be loaded throughout the thermal cycle. The load on the internal structure of a manned orbiting vehicle, for instance, can be described as high to moderate during the initial flight stages and as comparatively low during later stages. In other structural areas, the loading sequence may be just the reverse.

Besides the environmental considerations, such other factors as degree of flushness, fabricability, installation, replacement, reusability, reliability, and cost must be taken into account. In the end, Republic engineers hope,

IN BRIEF

In discussions of advanced aerospace structures, it's fairly easy to overlook something as humdrum as mechanical fasteners. But that doesn't mean that fasteners won't be used on these structures or that fasteners won't change as radically in the new environment as have other structural elements.

This report on the fastener development at Republic Aviation covers the completely new types of fasteners we will need for extreme environmental regimes. The most advanced hypersonic fasteners probably will use helical cam contact surfaces instead of threads. For temperatures up to 4500 deg F, fasteners are likely to be made from refractory alloys—and that means coatings will have to be used to provide oxidation resistance. In addition, new manufacturing processes will have to be developed.

Manned Space Probe

Steep Re-entry			Shallow Re-Entry		
Temperature (deg F)	Time (min)	Load Level	Temperature (deg F)	Time (min)	Load Level
3000-8300 2000-4000	1 60	high to moderate low	2800-4800 2000-4000	10 60	moderate
3000-4500 1500-3000	1 60	high low	2000-3000 1500-3000	10 60	low
3000-4500 1500-3000	1 60	high low	2000-3000 1500-3000	10 60	
2000-4000 1000-2000	1 60	moderate low	1800-2700 1000-2000	10 60	
2000-3000 500-1500	1 60	low low	1800-2700 500-1500	10 60	
3000-4500 1600-2500	1 60	high moderate	2000-3000 1600-2500	10 60	moderate
1000-1500 1000-1500	1 60	high moderate	1000-1500 1000-1500	10 60	

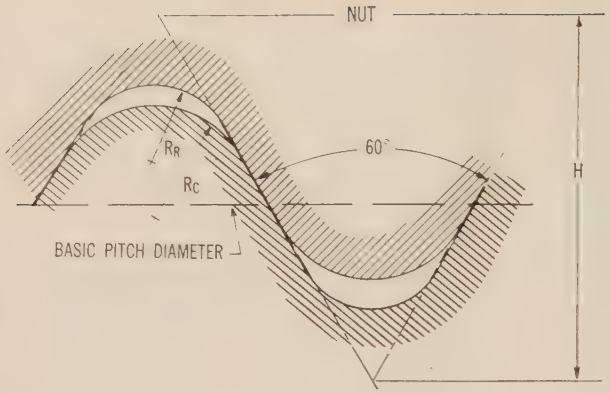


FIGURE 1: Advanced fasteners may use coarse pitches in Republic radius thread system (where $R_R = H/5 = 0.173p$ and $R_C = H/4 = 0.216p$). As the threads are designed around basic, unified 60-deg pitch diameters, the major diameter of the screw is 0.008-0.01 in. smaller than the nominal diameters. This makes it possible to regrind standard taps and protects the coating on the external threads during installation of bolts in close-tolerance holes. (Standard unified tolerances apply to all unspecified dimensions.)

they will come up with fasteners that can be used from —350 to 4500 deg F.

Studies of current steel and superalloy fasteners show that a number of changes will have to be made on coated fasteners of refractory alloy:

- For *shear and tension bolts and nuts,* the fillet radius must be increased at the junction of head and shank to minimize notch effects, the radius of all head contours must be increased to avoid local overheating at sharp projections, and thread contours must be modified to improve the basic material's notch strength. All these changes also are essential for making the coating more effective. Furthermore, there will be no locking devices requiring elastic lock behavior and pin and castellation systems.

Republic engineers point out that so far there are no suitable methods for coating threads. The deposits on thread crests are likely to be heavy and non-adherent and tend to spall after thermal exposure. Among the thread changes foreseen by Republic engineers is the use of coarse pitches in Whitworth and Republic radius thread systems (*Fig. 1*).

- For *blind fasteners,* explosives must provide heat detonation at temperatures beyond the ductile-to-brittle transition range and tapered mandrels must be used in place of threaded ones.
- For *common rivets and shear pins,* head-to-shank radii and the radii on all head contours must be increased, and lower-strength high-ductility refractory alloys should be considered for those parts of multi-component fasteners requiring large plastic deformation in installation.

Threaded fasteners to be avoided

Because of the serious problems of coating and brittleness at low temperature, threaded fasteners should be avoided. There's also the point that the high pressures developed in nut running and final torquing can damage thread coatings by cracking or spalling.

Table II: Properties of Refractory Alloys for Fasteners

	Status	Composition	Rupture Stress (ksi)								
			2000 Deg F			2200 Deg F			2500 Deg F		
			1 Hr	10 Hr	100 Hr	1 Hr	10 Hr	100 Hr	1 Hr	10 Hr	100 Hr
Columbium											
Fansteel FS-82	comm.	0.75Zr-33Ta	34	25	17.5						
GE F-48	comm.	1Zr-5Mo-15W	50	42	35	35	24	17			
Union Carbide Cb-74	semicomm.	5Zr-10W				25					
du Pont D-41	lab.	6Mo-10Ti-20W		20							
Molybdenum											
0.5 Ti			49	41	34	36	30	25			
GE 0.5 Zr	semicomm.	0.5Zr	50	42	35	41	35	30	27	18	13
TZM	comm. & semicomm.	0.5Ti-0.08Zr, 0.45Ti-0.07Zr		65[3]	52						
TZC	semicomm.	1.25Ti-0.3Zr-0.3C, 1.25Ti-0.15Zr-0.15C	53	45	39	42	35	30	24.5[3]	20.5	16.5
Tungsten											
Arc-melted											

(1) Temperature at which the strain-hardened structure of bar stock has recrystallized to produce equiaxed grains after one hour at temperature. (2) Partially recrystallized. (3) Estimated.

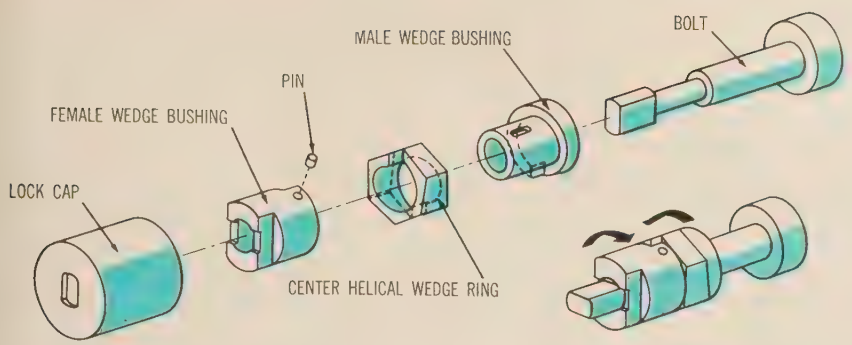


FIGURE 2: Republic double-helical wedge nut. (Patents are pending on this design and the ones shown in Figures 3 & 4.)

Republic therefore is working on fasteners relying on cam action instead of thread action and expected to be suitable for mass production. Cams increase the bearing areas and so reduce contact loading pressure and coating damage. They also make it easier to apply coatings, since now all surfaces are smooth and exposed.

An important benefit of using cams, Republic states, is that the nut expansion at high temperatures subtracts from the overall expansion of the bolt portion and so minimizes the relaxation. To gain this benefit, the nut is placed behind the contact surface of the bolt. Studies show that the nut probably can be made from a material with a higher coefficient of expansion than the bolt's. In this way, relaxation could be eliminated almost completely within a given temperature range.

Republic's new single-helical-wedge nut uses an unthreaded bolt with a necked-down portion near one end, so that a helical cam can be developed on the contact surface. This surface rides on the helical surface of the nut, providing a tightening action as the result of relative rotation of bolt and nut. The cam development on both bolt and nut is made on a countersunk surface, so that (1) the area of contact between bolt and nut surfaces is increased to minimize coating damage during tightening and loosening and (2) the bolt wedges into the nut when a torque is applied and the nut cannot shake loose. In effect, the nut also acts as a lock washer.

Locking cap for extra protection

A locking cap is placed over the nut for added protection against loosening. (It keeps the nut from rotating relative to the flat part of the bolt.) The inside surface of the cap is serrated to engage the corners of the nut. The cap is heated and expanded before being pressed on the nut—the subsequent shrink fit prevents coating damage.

Republic's double-helical-wedge is unique, its designers say, in more than doubling the normal take-up of

4100 Deg F			4500 Deg F			Room-Temperature (Bar) Ductility	Formality	Recrystallization Temperature (deg F)[1]	Remarks
.1 Hr	1 Hr	10 Hr	0.1 Hr	1 Hr	10 Hr				
						good, ~8-12% el.	excellent (cold)	2200	available from Allegheny-Ludlum & Crucible Steel
						good, ~8-12% el.	good (may require hot-forming—600-900° F)	3200[2]	Haynes Stellite attempting scale-up
						good, ~10% el.		2500	
						good, ~10% el.			
						good, 15-25% el.	cold-forming limited, hot-forming—preferred operations (400-900° F) 0-40° F (0.040-in. sheet)	2450	available from Climax Molybdenum & Universal Cyclops
						good, 8-12% el.		2650	sheet rolled by Universal Cyclops
						good, 15-25% el.		2700	available from Climax Molybdenum (bar) & GE
						good, 20% el.		3000[2]	available from Climax Molybdenum & Universa Cyclops
7.2	4.6	3.2	4.2	2.8	1.8	nil, ductility transition temp. above RT	poor, hot-forming mandatory (600-900° F)	3250	

quick-lock fasteners (*Fig. 2*). The take-up is increased by the simultaneous action of two cam surfaces without any loss in mechanical advantage, Republic claims. The mating cam surfaces fully engage during tightening to minimize chipping and galling of the coating.

In another case, Republic wanted to gain the advantages of full surface engagement but minimize the neckdown part of the bolt to greatly increase the bolt's tensile strength. It designed a split nut that collars fully around the neckdown and mates with a larger undersurface (*Fig. 3*). The nut is held together for assembly by the engaged section of the bolt on one side and the joint itself on the other.

A prototype of the single-turn, helical-wedge fastener has already been tested. The first test specimens were made of heat-treated 4130 steel at 100,000-125,000 psi tensile, a material that allowed comparisons with existing performance data and presented no machining problems other than those inherent in the contouring of the helix. After a suitable manufacturing technique had been evolved and reliable performance had been achieved, the fasteners were made from 0.5Ti molybdenum alloy.

Standard lathe had to be used

Design parameters specified a 45-deg, 8-pitch, double-lead thread, machined on the underside of the projections at the top of the bolt and mating with a similar surface on the top side of the nut. The only equipment Republic could use was a standard shop lathe. For the bolt, proper tools were ground, the workpiece was held in a collet, and the lead screw was engaged. The chuck was rotated by hand to cut the thread by advancing the tool for each pull through of the lathe chuck. Though this amounted to doing it the hard way, suitable

Table III: Coatings for Refractory Fasteners

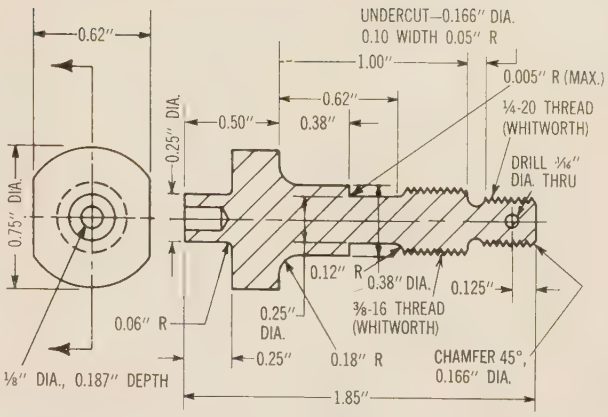
	Composition	Application	Static Oxidation Life (hr)	Remarks
Columbium Chromalloy Modified W-2	probably Cr-rich	modified pack deposition	320 @ 1800° F	good throwing power on irregular surfaces; tends to embrittle thin sections & sharp edges; not suitable for local patch-coating
Chromizing Durak-Cb	probably Cr-rich	vapor deposition	several @ 2500° F	good throwing power on irregular surfaces; assembly of coated fasteners hampered by lack of RT ductility; known patch-coating techniques
Fansteel S-2	probably Si-rich	vapor deposition from $SiCl_4$	2 @ 2500° F	good throwing power on irregular surfaces; tends to embrittle thin sections & sharp edges; not suitable for local patch-coating
General Electric Aldico	Al-10Cr-2Si	hot dip plus diffusion treatment	2 @ 2500° F	difficult to apply to threaded fasteners; diffusion treatment difficult on large structures
LB-2	Al—11Si+pure Al	cold dip in slurries plus diffusion treatment	2 @ 2500° F	
Horizons	Ni+(Si+Cr)	fused-salt electroplate	1 —3 @ 2500° F	difficult to plate irregular contoured pieces; not reproducible complex application procedure; not reproducible; flame-spraying tends to fill in recesses & miss sharp edges
	34Si—20 Al plus dip in molten Al	flame-spray	1 —6@ 2500° F	
Thompson-Ramo-Wooldridge	Cr+Ti+Si	vapor deposition	10 @ 2500° F	good throwing power on irregular surfaces; oxygen tends to diffuse through to base metal
Union Carbide	4 mils of proprietary material plus 4 mils of modified $MoSi_2$	flame-spray	6-10 @ 2730° F	good static oxidation, thermal shock, self-healing characteristics; flame-spraying tends to fill in recesses & miss sharp corners

bolt head helices were cut. For a production run, Republic's method could be adapted to an automatic machine tool.

Tool problems developed when the chip removal was used to produce the nut. These included poor cutting action, excessive clearance, and insufficient strength. Clearly a better way of making the nut was needed.

The best method of nut contouring, Republic decided, was electro-chemical machining. An Anocut unit with a basic 300-amp power pack was used in combination with a special machine tool (*Fig. 4*). A cathode tool with the nut-helix configuration was outlined, electrolyte was passed through the tool and, by means of a pot chuck, up through a hole drilled in the anode workpiece to insure ample pressure and flow for the cutting action.

Another manufacturing problem was the profiling of the oblong hole in the nut. Spark-erosion machin-



EVALUATION specimen for Republic coating tests.

	Composition	Application	Static Oxidation Life (hr)	Remarks
Molybdenum Chromalloy W-2	modified chromized coating	pack deposition in reducing atmosphere	1 @ 3000° F	good thermal shock resistance; good stress induced deformation at ambient temperatures; some self-healing at 3000° F; good hot erosion resistance; good throwing power; patch coating possibilities; brittle at RT
Climax Molybdenum	20Al—40Cr—40Si	flame-spray plus prediffusion treatment	4 @ 3000° F	good thermal shock resistance; good stress-induced deformation at ambient temperatures; self-healing tendencies above 2600° F; fair hot erosion resistance. Tends to fill in recesses & miss sharp corners; poor ballistic impact resistance at ambient temperatures
Fansteel	$MoSi_2$ & modifications	vapor deposition from $SiCl_4 + H_2$ atmosphere above 2000° F	100 @ 3000° F (1414 for boride mod), 28 @ 3400° F 28 @ 3600° F	excellent reliability; good thermal shock resistance; fair stress-induced deformation above about 1800° F; some self-healing tendencies above 2800° F; good hot erosion resistance; good throwing power; application temperatures may cause recrystallization of base metal; brittle at RT; no known patch-coating techniques
Tungsten Chromalloy T-1	modification of W-2	pack deposition in reducing atmosphere	1 @ 3000° F	good throwing power; brittle at RT
	zircon-Pyrex mixture over WSi_2	vapor deposition of WSi_2 flame-spray or slurry-dip plus diffusion treatment of zirconium silicate Pyrex glass mixture	several @ 3000° F	in early stages of lab development

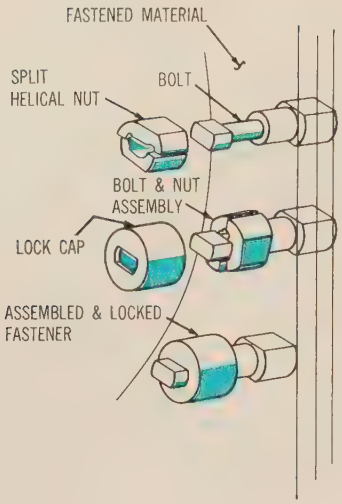


FIGURE 3: Split nut increases tensile strength by minimizing the neckdown portion of the bolt.

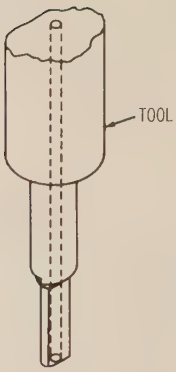


FIGURE 4: Cathode tool for electrochemical machining of nut helix.

ing and push-broaching were used to overcome it.

As its program progresses, Republic is planning to produce more fastener types: a ¼-in.-diameter protruding-head, threaded tension bolt; a ¼-in.-diameter 100-deg-flush-head, threaded shear bolt; a 5/16-in.-diameter Hi-shear rivet; a 5/16-in.-diameter flush-head, explosive rivet; a ⅛-in.-diameter brazier-head, common rivet; a 5/16-in.-diameter mechanically expanding blind fastener; and a ¼-in.-diameter special threadless bolt.

Republic made materials survey

After making a materials survey, Republic decided that columbium-base alloys should be considered for 2700+ deg F, molybdenum-base alloys for 3000+ deg F, and tungsten for up to 4500 deg F (*Table II*). Specifically, three columbium, three molybdenum, and two tungsten alloys, Republic's engineering report points out, seemed best for the program:

- "F-48 . . . is the strongest columbium base material commercially available. Use is contemplated for highly loaded fastener components.
- "D-41 [columbium alloy] is currently a laboratory item with strength approaching that of F-48 but with considerably improved oxidation resistance. Its use seems advantageous for blind fastener fabrication when irreparable coating damage may exist at highly deformed location. In this use, suitable performance may be obtained, especially under the static oxidizing conditions present in internal structure and despite the lack of access to make repairs to a damaged coating.
- "[For] Cb-74 [columbium alloy], the strength criteria have been relaxed . . . to exploit the high room temperature ductility (30 per cent elongation in one inch) in certain fastener components demanding large plastic deformation for locking during installation. Current test fasteners employ the lower-strength Fansteel 82B or 10Ti columbium for components demanding a high order of ductility.
- " . . . Molybdenum base alloy recommendations for temperatures in the vicinity of 3000 deg F are 0.5Zr molybdenum, TZM, and TZC. Selection is premised on greater strength potential within [the] 2000-3000-deg F range than [that of] 0.5Ti molybdenum and availability on a commercial or semi-commercial level. All of the molybdenum alloys selected are capable of sufficient ambient-temperature ductility to permit a fair amount of installation ductility and hence a single-alloy fastener design. In addition, protective coatings are available for use up to and slightly above 3000 deg F.
- Tungsten-base alloy recommendations for temperatures not exceeding 4500 deg F are 15Mo-0.2Zr tungsten and 7Mo-0.2Zr tungsten. . . . The former [is] rapidly becoming a standard material for . . . rocket nozzle insert applications, where it has exhibited excellent resistance to extreme temperatures and thermal shock. The latter . . . is included [for use when] a higher tungsten content . . . is desired. Both alloys have been successfully arc-melted by Oregon Metallurgical Corp. and forged into useful shapes by Ladish Co. and others."

Coating selection is critical

Oxidation resistance, of course, is the Achilles' heel of the refractories, so that coating selection becomes critical for advanced fasteners (*Table III*). For columbium, some of the more promising coatings are GE's hot-dip Al-Cr-Si and cold-slurry LB-2 and Cr-Ti-Si. The first two, Republic engineers state, offer good protection and are easy to apply to fasteners; the vapor-deposited Cr-Ti-Si is being developed by Thompson-Ramo-Wooldridge for long-time protection. Vapor deposition would make it easier to apply uniform coatings on irregular configurations and threaded section.

A large number of coatings for molybdenum is under development, and therefore a fairly detailed evaluation will probably be needed to find the one best suited for fasteners. Very little work has been done on coatings for tungsten. The only project reported in the literature was run by Arthur Friedberg at the University of Illinois and involved the deposition of a tungsten silicide substrate plus an overlay of zircon-silica glass to protect tungsten wires tested in air for several hours at 3000 deg F. Studies by H. Pearl at Republic show that Chromalloy T-1 gave no protection in flowing air for periods of four hours at above 2600 deg F.

The coating methods by Republic include electrodeposition from aqueous solutions or fused salt baths, vapor deposition, pack diffusion, roll cladding, spraying, liquid-phase diffusion, and dip. Republic says that several of these methods—especially electrodeposition, vapor deposition, and dipping—seem preferable for fasteners in terms of uniform coating thickness.

Lithium propellant

shows low combustion losses

by M. C. Hardin and A. I. Masters, Section Chief & Research Engineer, Allison Div., General Motors Corp.*

MOST OF the light metals—lithium, beryllium, boron, sodium, magnesium, aluminum—are being considered for use as rocket fuels. Lithium rates high among them chiefly because of the high theoretical specific impulses of several lithium-oxidizer combinations (*Table I*). The heat of formation of such condensed products as LiF, Li_2O, and LiOH is much larger than that of HF and H_2O (*Table II*). As the specific impulse is proportional to the square root of the chemical energy converted to useful work, the additional energy from a lithium-fluorine system would represent an increase of one-third in specific impulse, assuming the expansion efficiency of the LiF system equals that of the H-F system.

Lithium also has several other promising physical characteristics (*Table III*):

- It has a lower melting point than any other metal

* Allison Div., General Motors Corp., Indianapolis 6, Ind. The authors wish to acknowledge the assistance of Dr. C. F. Warner, of Purdue U., and of Callery Chemical Co., Becco Chemical Co., Arthur D. Little, Inc., and Lithium Corp. of America.

Table I:
Theoretical Specific Impulse of Lithium (sec)*

Oxidizer	Pressure Ratio 1000:14.7	500:14.7	500:14.7
Liquid fluorine (frozen expansion)	350	326	380
Liquid chlorine-trifluoride			
Frozen expansion	298	278	322
Equilibrium expansion	330	292	
Liquid oxygen (frozen expansion)		227	281
Liquid hydrogen peroxide			
Frozen expansion		255	305
Equilibrium expansion		256	313
Water (Li & H_2O at 500 deg F, frozen expansion)	243		

* For optimum fuel-oxidizer ratios.

IN BRIEF

In a study of the advantages and disadvantages of lithium as a rocket propellant, experimental rocket motors firings were made with chambers of different sizes and characteristic lengths at varying ratios of liquid lithium to 90 per cent hydrogen peroxide. The results of the tests provide some information on the Li-O-H reaction and show that the existing thermodynamic data on lithium reaction products are unreliable. Exhaust nozzle erosion and chamber burnout posed serious problems. Apparently they were caused by very high heat transfer due to the condensation of lithium oxide on nozzle and chamber. Nevertheless the test data show that the problems of working with liquid lithium are not as bad as might have been expected.

Table II: Heat of Formation of Light Metal Reaction Products (btu/lb)*

	Solid	Gas
LiF	10,069	5,385
LiOH	8,748	4,648
Li_2O	8,589	2,281
BeO	10,299	2,188
BeF_2	8,692	6,542
B_2O_3	7,891	5,304
AlF_3	7,624	6,083
MgF_2	7,611	5,152
BF_3		7,168
Al_2O_3	7,070	4,524
HF		5,775
H_2O		5,773

* From elements in their standard state.

Table III: Physical Properties of Lithium Metal*

Molecular Weight	6.940
Density	
At 77 deg F	0.534 gm/cm³
At 400 deg F	0.506 gm/cm³
Melting point	357 deg F
Boiling point	2371 deg F
Heat of fusion	219 btu/lb
Heat of vaporization	8440 btu/lb
Viscosity (392 deg F)	0.565 cp
Specific Heat	
Solid at 357 deg F	0.991 btu/lb
Liquid at 357 deg F	1.048 btu/lb
At 1832 deg F	0.991 btu/lb
Therma 'conductivity	21.7 btu/hr-ft-deg-F

* From Lithium Corp. of America.

except sodium and therefore can be used in a solid propellant, as the solid fuel of a solid-liquid hybrid rocket, and in the liquid state as a propellant or as the working fluid in nuclear rockets.

• High chemical reactivity makes the solid metal hypergolic with many materials and the liquid hypergolic with most common oxidizers and provides high combustion efficiencies.

If we exclude the hydrogen systems, lithium-flourine has a higher specific impulse than any other bipropellant, while lithium-chlorine trifluoride has the highest specific impulse among non-cryogenic bipropellants. Lithium-oxygen doesn't look attractive, even assuming that its performance has been understated by as much as 10 per cent. The competitive position of lithium-hydrogen-peroxide can't be estimated accurately because of unreliable thermodynamic data, but this combination looks promising.

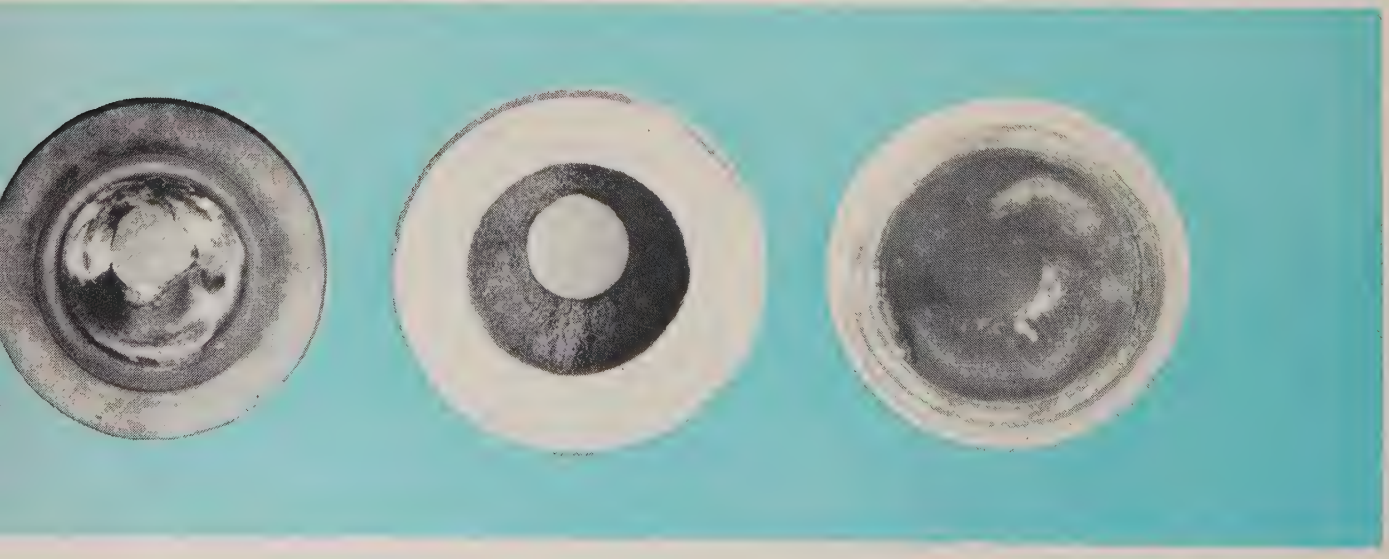
In fact, it was lithium-hydrogen-peroxide that we used in our first experimental study of lithium as a rocket propellant. This combination appeared to have the greatest immediate potential, it was simpler to work with than the fluorine systems, with their extremely high chamber temperatures, and offered the best chance for better thermodynamic data on lithium combustion.

Lithium injected into decomposed H_2O_2

In a 200-lb-thrust motor, we injected liquid 500-deg-F lithium into decomposed 90 per cent H_2O_2. Our experimental rocket was kept as small and simple as was compatible with obtaining valid performance data. It was uncooled—partly for reasons of simplicity and economy and partly because the thin walls required for liquid cooling might have burned through too quickly.

The H_2O_2 was injected through a catalytic decomposition chamber, in which it was broken down into oxygen and water vapor at about 1360 deg F. A variety of single-point lithium injectors were tested in combustion chamber segments with characteristic lengths ranging from 50 to 300 in.

FIGURE 1: Lithium hydrogen peroxide caused severe throat erosion of exhaust nozzles. L. to r.: copper nozzle after 2.1 seconds, graphite nozzle after 2.3 seconds, and tungsten nozzle after 1.9 seconds.



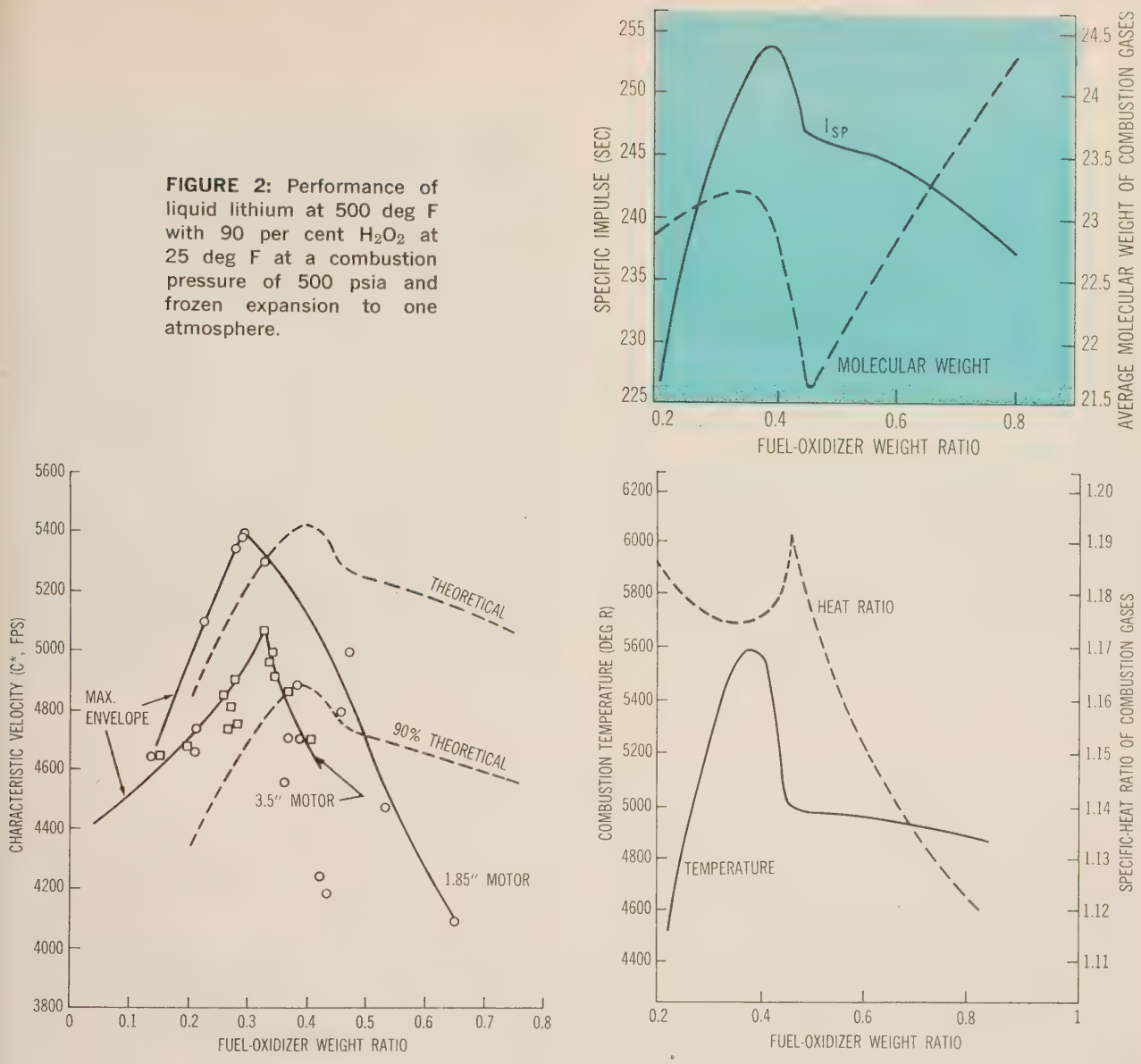


FIGURE 2: Performance of liquid lithium at 500 deg F with 90 per cent H_2O_2 at 25 deg F at a combustion pressure of 500 psia and frozen expansion to one atmosphere.

Except for the exhaust nozzle, all the basic components of the motor were made of 30310 stainless steel. The nozzle materials included copper, graphite, and plasma-sprayed tungsten over graphite.

The first 21 test runs—out of a total of 36 successful ones—were made with a 1.85 in.-diameter chamber. After all runs with this chamber, the nozzles showed extreme erosion (*Fig. 1*). In one case, the chamber burned out in less than 2½ seconds.

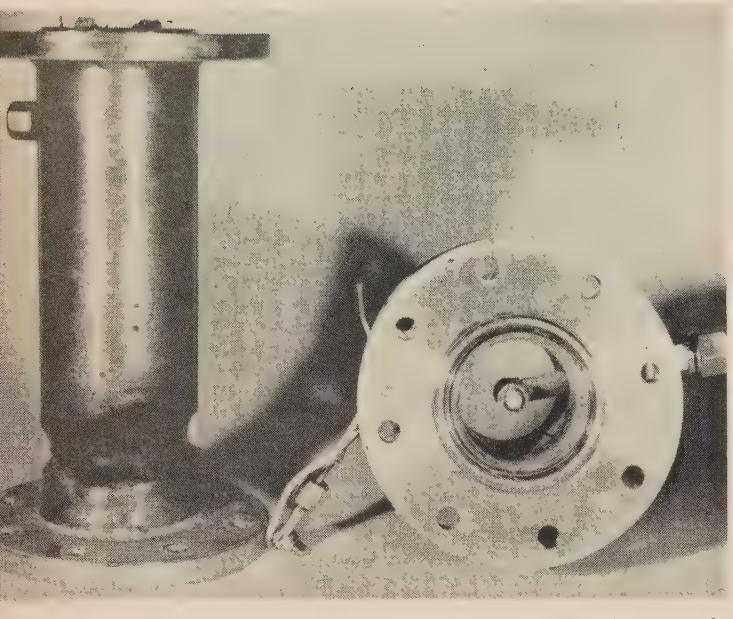
We decided that a chamber of larger diameter might improve results. It would give us greater flexibility in injector design without risking lithium impingement and it would reduce the gas velocity at the nozzle entrance, improving the boundary layer conditions in the nozzle and possibly reducing erosion.

In 15 firings with a 3.5-in.-diameter chamber, the problem of burnout had almost completely disappeared. Nozzle erosion was greatly reduced but remained serious. With tungsten-coated graphite nozzles it amounted to a 3-10 per cent diameter increase in runs lasting 3-7 seconds.

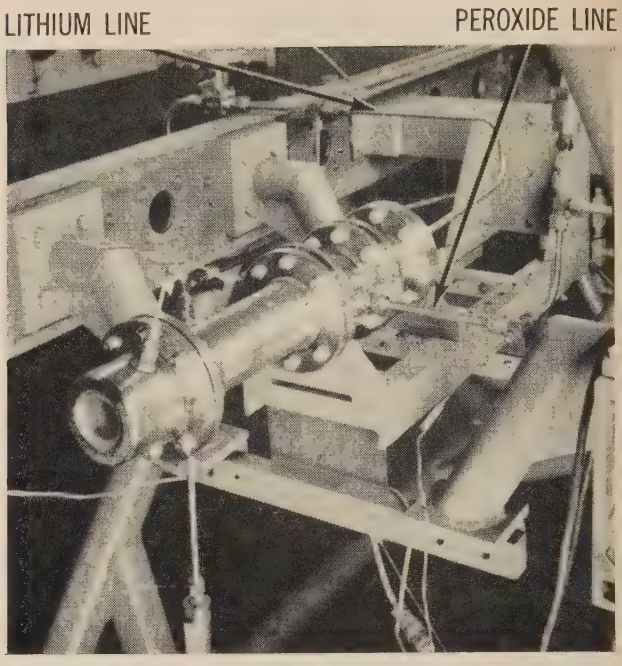
The logical explanation of the severe nozzle erosion is that lithium oxide condenses on the nozzle surface and greatly increases the local heat transfer rate. On the assumption that the equilibrium combustion temperature substantially exceeded the theoretical values and that condensation quickly raised the nozzle surface temperature close to the level of the gas temperature, a high erosion rate for graphite nozzles was no surprise.

The final firing of our test series was made with a water-cooled copper nozzle to get data on heat transfer rates and check our theory about the cause of the erosion we had observed. Our calculations predicted a heat flux of 20 btu/sq in/sec at the throat, excluding the effect of condensation or recombination on the nozzle surface. In the test, the nozzle liner burned out 0.57 seconds after the lithium flow had started. The peak heat was measured at 50 btu/sq in/sec, and would probably have been higher if stabilized conditions had been reached before burnout. This high heat flux strongly supports the argument that nozzle erosion was caused primarily by the heat transfer from condensing exhaust products.

Because of the rapid erosion of the exhaust nozzles we could not use the conventional parameters of characteristic velocity (c*) and thrust coefficient C_F for the performance analysis of the data from our 36 test



COMBUSTION chamber and injector after burnout in 2.3 seconds.



EXPERIMENTAL rocket motor mounted on thrust platform and instrumented for firing tests.

runs. Instead we used an assumed ideal C_F based on our measurements of propellant mixture ratios (which covered a wide range) and chamber pressures. The result is experimental c^*-efficiencies that include both c^*- and C_F-losses (*Fig. 2*). The highest c^* for the 1.85-in.-diameter motor was 5410 fps at a fuel-oxidizer ratio of 0.290. This was four per cent more than the theoretical value. For the 3.5-in.-diameter motor, the highest c^* was 5070 fps, which was 4.5 per cent less than the theoretical value.

The high level of measured performance in comparison with the theoretical data comes as a surprise when you consider all the losses built into our setup. Our low-thrust motor could be expected to have high heat losses, particularly with the large characteristic lengths that we used; there was severe nozzle deterioration (especially at the throat), which caused turbulence and underexpansion; and there must have been the normal losses due to angularly directed exhaust components, frictional effects, and other aspects of imperfect expansion, which usually amount to 1-2 per cent of the theoretical thrust coefficient.

The effect of these performance losses can be quite significant. Even when they are conservatively estimated, they indicate, coupled with the high measured c^*-values, that the theoretical performance values in *Figure 2* are 5-15 per cent too low.

The peak in the c^*-values at a lean fuel ratio is undoubtedly due to incomplete combustion of the lithium at near-stoichiometric conditions. An injection system with better distribution than our single-point spray nozzle therefore should give better performance at these fuel-rich conditions. This peak also confirms calculated equilibrium composition, which gives LiOH as the major reaction product. It would have occurred at a higher fuel-oxidizer ratio if Li_2O were a significant constituent at optimum c^*.

The higher performance of the smaller combustion chamber is probably due to a combination of better fuel distribution and reduced heat loss. A wider injection spray angle with better distribution did not affect performance appreciably, so that it appears that the chamber's greater heat loss was mainly responsible for the lower performance.

In all cases, the lithium was hypergolic with the decomposed hydrogen peroxide. The atomized liquid lithium was also pyrophoric. Ignition delay in all cases occurred without any significant pressure rise. We measured high-frequency oscillations of 800-1000 cps in every test, but normally their amplitude was only 1-5 psi—only once did it exceed 20 psi. We therefore concluded that combustion was very stable.

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Digital-analog hardware simulation backs up Polaris design

by C. H. Kaufmann, Supervisor, Guidance & Simulation, Research Laboratories, Lockheed Missiles & Space Co.*

ANALOG AND DIGITAL simulation proved invaluable in the development of the underwater-launched Polaris IRBM. It enabled us to spot interface and design deficiencies in advance of flight testing and to diagnose and correct malfunctions that showed up in flight tests with a minimum of time and effort.

The Polaris simulation program covers all phases of the solid-propellant missile's flight—from in-tube acceleration to impact (*Fig. 1*). In addition, launches from surface ships, land-based pads, and ship-motion simulators can be duplicated.

Highly accurate impact computations are used to evaluate the performance of the guidance system, which is a self-contained inertial design that consists of a stable platform and a digital guidance computer and steers the missile until final burnout. The target data are pre-fed into this system from the shipboard fire control system. Simulated environmental conditions and component characteristics are used to check out the flight control system of the aerodynamically unstable missile. This system basically consists of an autopilot and thrust-deflecting jetavators.

This comprehensive simulation program requires both analog and digital computation and simulation, and of course is tied in with the actual hardware wherever possible. Essentially, the digital program simulates—on an IBM 7090 computer—the principal phases of the Polaris trajectory for quick and simple evaluation of various configurations and situations. Analog simulation tied in with the actual hardware is used to verify the 7090's computations.

For the digital simulation, a programed six-degree-of-freedom trajectory routine is used. The pre-launch program simulates all the stages of the countdown, including erection, alignment of the inertial platform, and insertion of the guidance pre-settings. Inertial guidance system errors that affect erection and the alignment of the platform are included.

The computations of submarine motion are based on

* Lockheed Missiles & Space Co., Sunnyvale, Calif.

IN BRIEF

The Polaris simulation program is made up of six-degree-of-freedom trajectory routines, programed for a digital computer and equivalent mathematical models applied to an analog computer and actual hardware. On the basis of digital computer simulation, guidance accuracy is evaluated, while the analog-hardware setup simulates actual flight control and guidance system components. The trajectory computer program includes the effects of submarine motion and sea-state parameters on the early phases of the missile's flight.

With the help of the simulation program, design studies are verified, interface and design deficiencies are spotted in advance of flight testing, and malfunctions in actual flight tests are diagnosed.

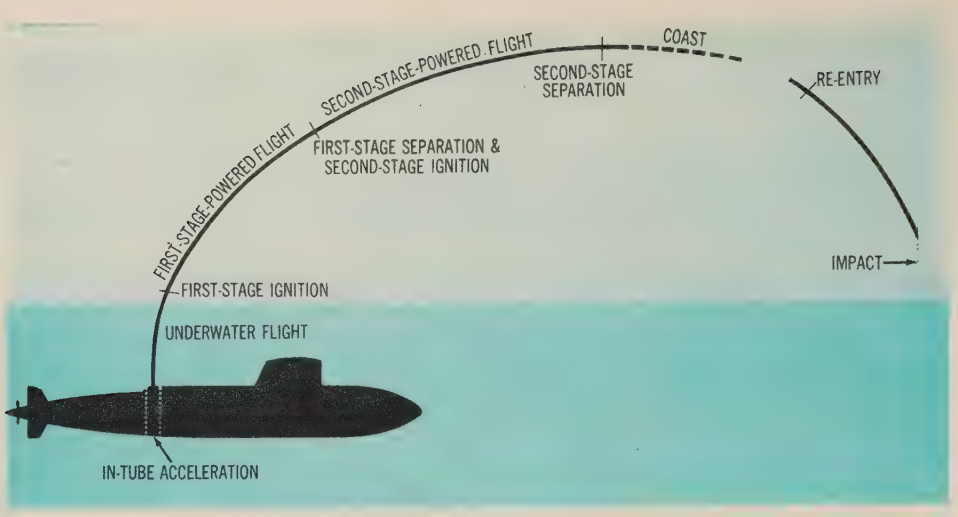


FIGURE 1: Polaris trajectory sequence.

a coordinate frame fixed to the sub. They cover the sub's heading, speed, pitch, yaw, roll, keel depth, and position. The effects of the "slippers" that constrain the Polaris as it is pushed up through its tube by compressed air are also included.

During underwater flight, the Polaris is subjected to hydrodynamic forces and moments that, for purposes of computation, are separated into components dependent on and independent of the missile's translational accelerations. The exact position of the air-water interface is simulated, as are sea-state parameters like wave height, amplitude, and direction. The computation of all these effects is based on an orthogonal coordinate frame fixed to still water.

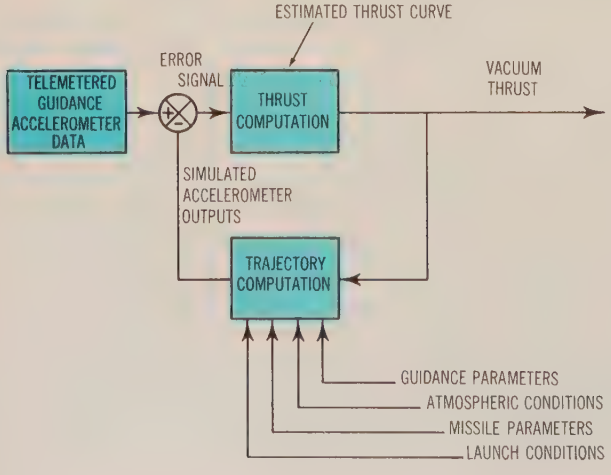
To determine the propulsion characteristics for powered-flight simulation, the engine's vacuum thrust-vs-time data are loaded into the computer routine. From these, thrust at altitude, losses due to thrust-vector control, mass loss due to propellant burning, and subsequent effects on weight, moment-of-inertia, and CG locations are calculated.

The missile dynamics are simulated in six degrees of freedom—three rotations and three translations. The aerodynamic coefficients are computed as functions of dynamic pressure and Mach number with double-table look-up programing. Autopilot gains, feedback sensors, limit levels, and the significant frequency response and non-linearities of the jetevators' hydraulic servos are simulated, while the characteristics of effective side force vs jetevator deflection are inserted in the computer for each flight.

For guidance-system simulation, coordinate systems fixed to the platform gimbals and accelerometer sensors are used. The scale factor, bias, non-linearity, and misalignment of the guidance accelerometers are simulated, as are platform misalignment and the effects of acceleration-sensitive and constant gyro drift rates on platform orientation. Continuous-form equations that approximate the steering equations are included in the routine.

Atmospheric conditions during the ascent phase are accounted for by the insertion of wind gusts and shear profiles as functions of altitude and of density variations from the ARDC standard atmosphere. The same conditions are inserted for re-entry, while for the coast phase two mathematical models are used: a Kepler ellipse and a three-degree-of-freedom point mass including re-entry body drag effects.

FIGURE 2: Determination of missile thrust characteristics.



Inertial frame is basic reference

Provisions are made for rotating and non-rotating spherical, ellipsoid, and flat earth models. The coordinate systems for computation and print-out include earth, inertial, and missile reference frames. The basic reference is an inertial frame centered at the earth's geo-center, with one axis parallel to the earth's spin axis. The firing frame, in which linear accelerations are integrated, is an inertial system aligned with the firing axis and erected to local gravity at the launch point. The missile coordinate system, in which the missile moments and forces are summed, is centered at the CG and fixed along the principal missile axes.

For flight-test evaluation, comprehensive test data for each flight, including measured guidance-system errors and launch conditions, are loaded manually and automatically. "Trajectory matching" can be used to determine the missile's precise thrust characteristics.

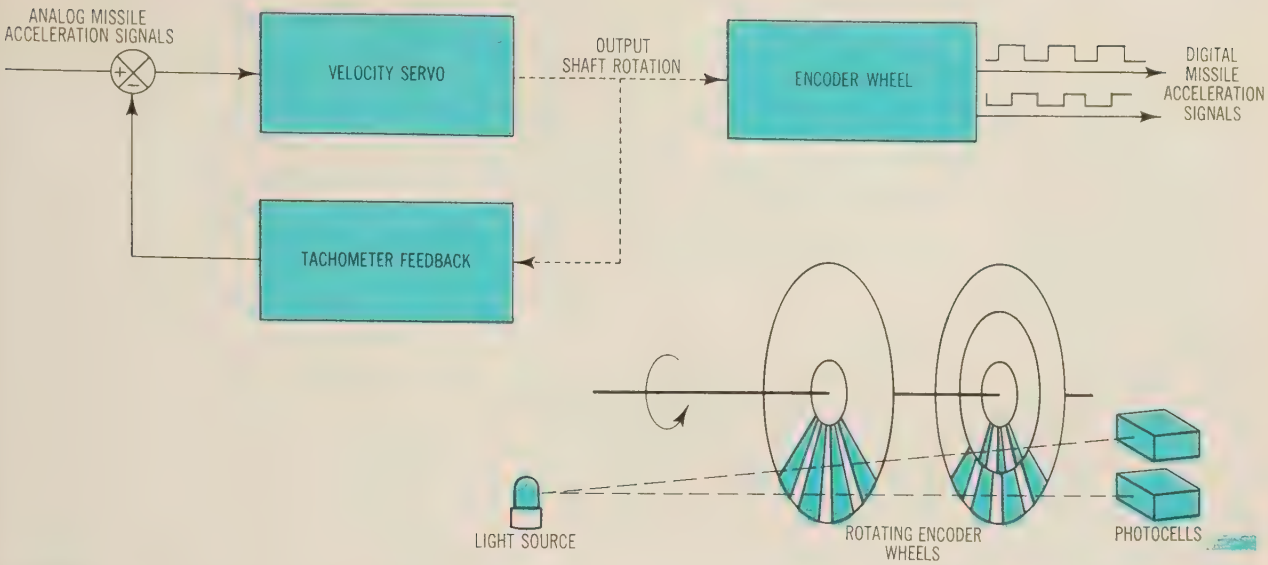


FIGURE 3: Analog-digital conversion system.

Basically this technique requires the manipulation of the trajectory by continuous adjustment of the thrust profile until the simulated and the telemetered accelerometer data agree *(Fig. 2)*.

For computation of missile dynamics in real time as well as for other simulation problems, analog computers that tie in with hardware are used. Actual hardware is tied in as much as possible because non-linear and other unique properties of guidance and flight control hardware are difficult to simulate.

Missile-motion equations vary

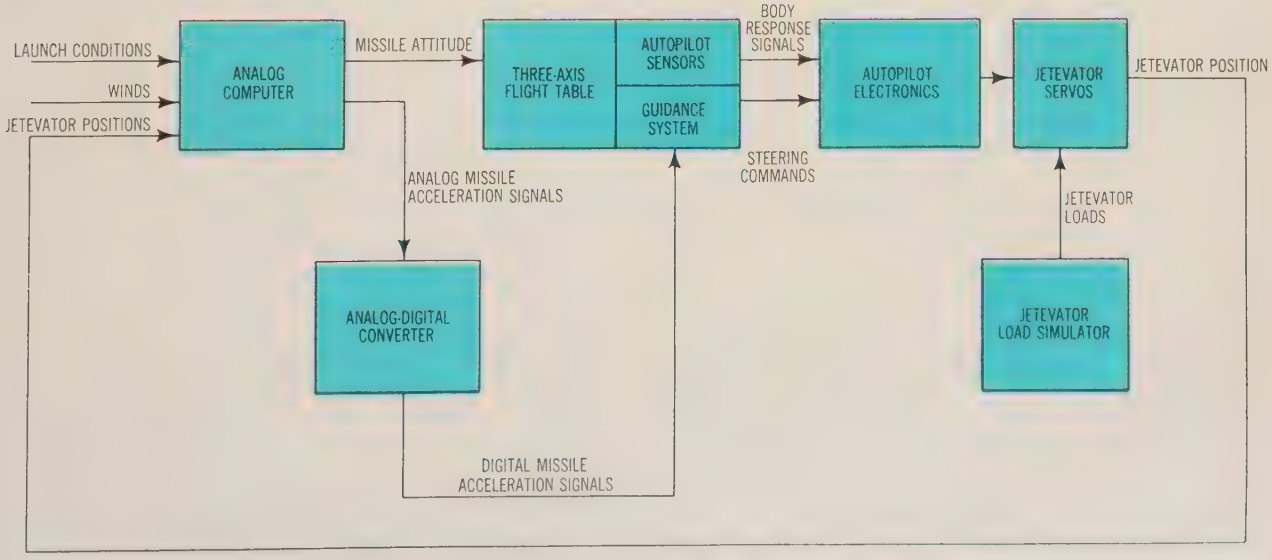
The six-degree-of-freedom model mechanized on the analog computer closely approximates the model of the digital computer program. The equations of missile motion vary depending on the complexity of the problem and the degrees of freedom under consideration.

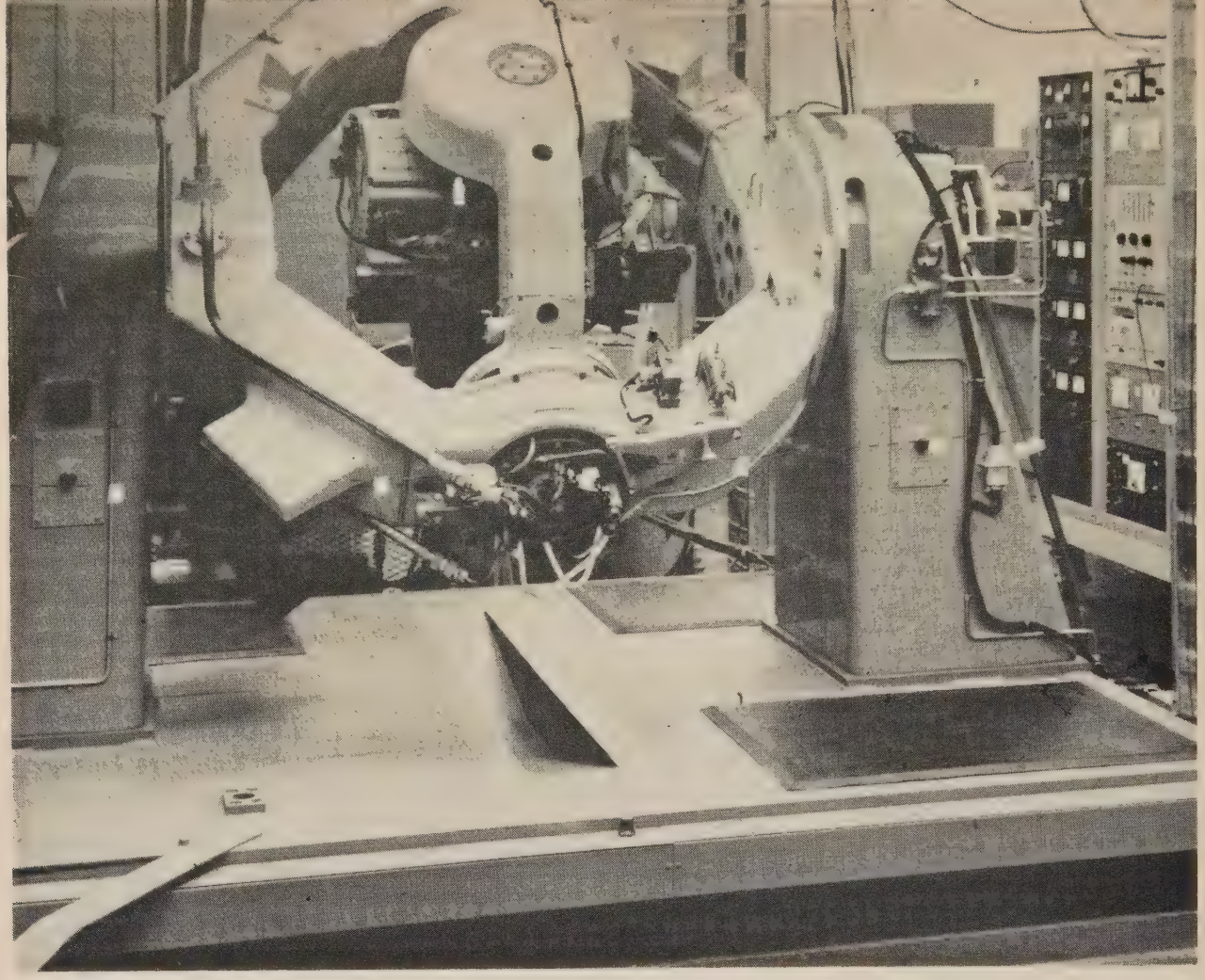
The flight hardware used in the simulation program consists of the autopilot electronics package, the flight control sensors, and the first- and second-stage jetevators. First- and second-stage flight control systems for two missiles can be operated simultaneously.

Because the principal non-linearities of the Polaris flight control system are introduced by the jetevator servos, the aft sections of the first- and second-stage motors were removed from a missile and set up in the flight control lab. Mounted on these aft sections are the jetevator assemblies and their hydraulic servos. A servo-controlled hydraulic load simulator is mounted on each jetevator to duplicate the spring forces produced in flight. A conventional prony brake simulates constant load torques.

Support equipment to operate the flight control hardware includes modulators and demodulators to convert the analog computer guidance signals, hydraulic equipment for the jetevator servos, and a flight control console to operate the electronic portions of the flight

Figure 4: Typical setup for closed-loop evaluation studies.





THREE-AXIS flight table for missile flight simulation.

system. All significant signals in the flight-control system can be monitored and recorded.

In the guidance lab, a three-axis flight table simulates angular motion to determine its effect on the guidance system and autopilot sensors. The guidance package and autopilot sensors are mounted on the inner gimbal. Missile attitude signals from the analog computer position all three table gimbals, reproducing the missile's rotational motion. The hydraulically controlled flight table is designed for a 300-lb load and a 65-in.-lb-sec^2 pitch moment of inertia and has negligible phase shift or attenuation in the region of the missile's response frequencies.

Analog-digital conversion needed

To tie in the analog computers and flight control hardware with the digital missile guidance computer, analog-digital conversion is required. Signals representing missile accelerations along the guidance axes are applied as inputs to a velocity servo (*Fig. 3*). The servo output shaft rotates encoder wheels modulating light beams. This optical modulation is sensed by photocells, and the resultant signals are rectangular digital pulses.

Both analog and digital support equipment for the guidance system is used during simulation. The analog equipment erects and aligns the inertial platform and provides earth rate corrections and other functions. The digital equipment inserts navigation pre-settings into the guidance computer and also works out sample problems on the computer to insure proper operation.

In the guidance lab, analog signals are recorded on conventional X-Y plotters and Sanborn recorders. Digital signals are monitored and recorded by a special "guidance digital evaluation unit." Digital data can also be summed by reversible counters, converted to analog form by ladder networks, and presented as a trace on Sanborn-type recorders. A high-speed printer reads out digital data at selected time values.

Figure 4 shows a typical set-up for closed-loop evaluation. The equations of motion are simulated by the analog computer and flight perturbations like winds and launch motion are inserted. The missile acceleration components along the guidance accelerometer axes are computed by the analog computer and converted to digital form. The digital signals then are applied to the guidance computer.

The missile attitude components computed by the analog computer position the three-axis flight table. The output signals from the autopilot sensors and guidance system mounted on the table are sent to the flight control electronics system. The jetevator servos are positioned by the autopilot signals, and the jetevator loads are simulated. Finally the jetevator deflection signals are returned to the analog computer, closing the loop.

Arc-imaging furnace

tests materials in high thermal flux

by Octave Romaine, Associate Editor

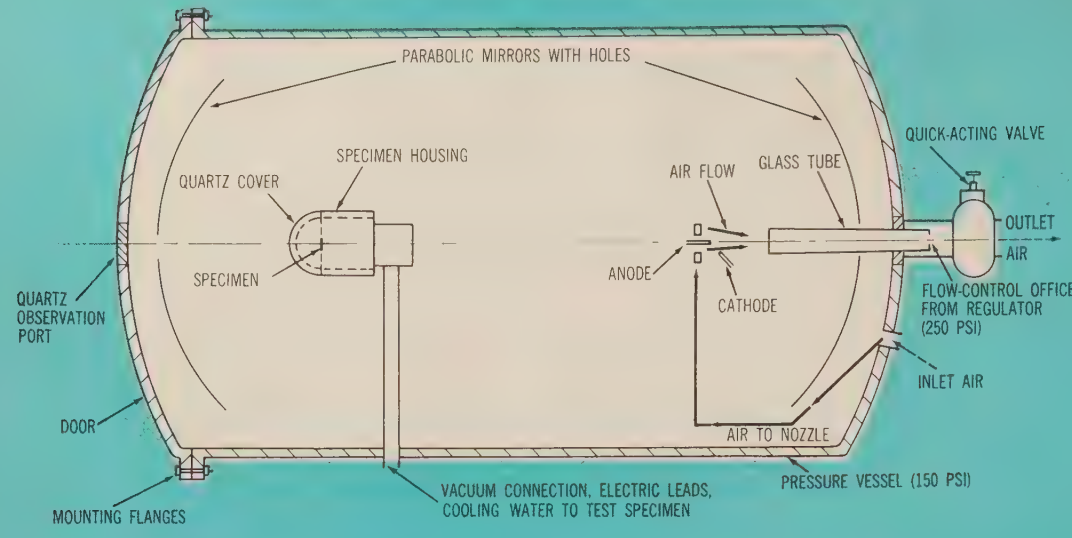
THE ARC-IMAGING furnace used for high temperature materials evaluation and research at Southwest Research Institute, 8500 Culebra Rd., San Antonio, Texas, can produce thermal fluxes in the range from 50 to 600 cal/cm²/sec (185—2230 btu/sq ft/sec) on a routine basis. The upper limit corresponds to a black-body radiation temperature of 4500 deg K at the specimen. The arc temperature is about 1100 deg higher to make up for geometric and absorption losses in the optical collecting system.

The furnace has twin, 36-in.-diameter parabolic searchlight mirrors with six-inch-diameter holes to collect the radiation from a carbon arc and focus it on a test specimen (see *Schematic*). Radiation is limited to the anode ball portion of the arc, the region of maximum temperature, by continuous purging of the arc with a high-speed air stream. The air blast carries away the flame, combustion products, and ionized gas layers to keep the anode ball from being obscured by intervening lower-temperature sources.

IN BRIEF

An arc-imaging furnace delivering thermal fluxes as high as 600 cal/cm²/sec to a specimen in a very pure form is being used at Southwest Research Institute. This thermal flux facility is used for materials research such as the study of high-temperature properties, comparative performance evaluation under specified thermal-flux and atmospheric conditions, determination of thermal constants, and investigation of heat transfer.

The furnace system is contained in a pressurized vessel, and the arc itself is pressurized. Specimens can be tested either under pressure or in a low vacuum. Testing is precisely controlled by an automatic timing and sequencing system, and there is provision for direct observation, photographic recording, emissions and absorption spectroscopy. Time-temperature tests of thermal diffusivity are made by embedding thermocouples in the specimen and recording their measurements on a galvanometric oscillograph. Thermal levels are calibrated with a black-body calorimeter. A cadmium sulfide photoconductive cell is used to monitor the tests and to measure short-term variations in the thermal flux that cannot be measured with the calorimeter.

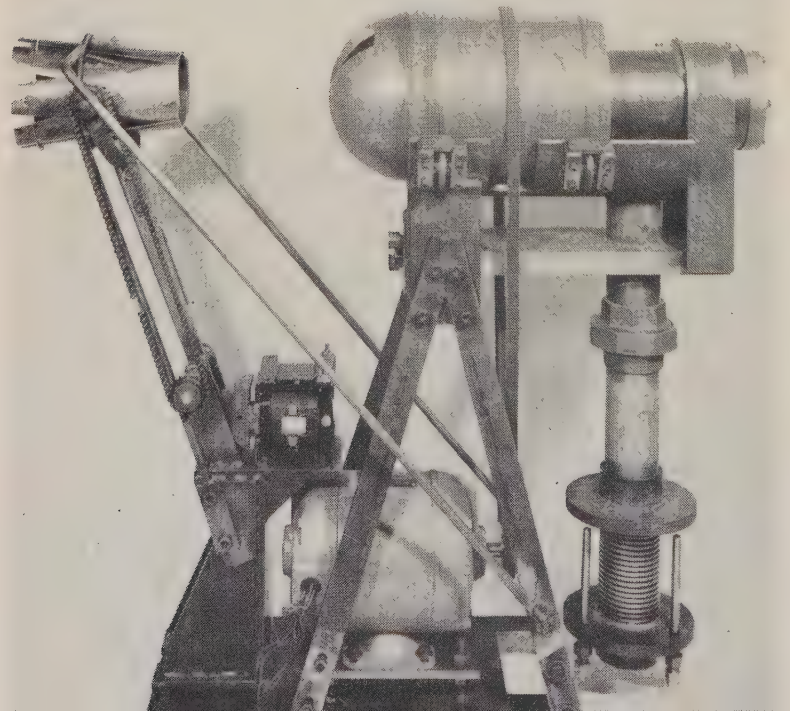


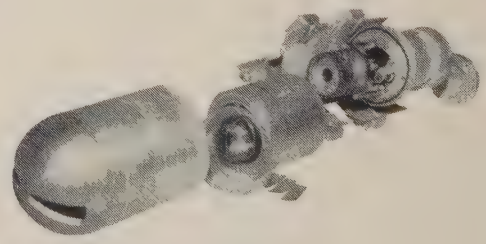
ARC - IMAGING system inside its pressure vessel. The arc and specimen are at the focal points of the two mirrors.

The entire arc-imaging system is contained in a pressurized vessel. The air blast also maintains the system pressure while cooling the interior and removing the arc products from the optical path. The specimen is located at some distance from the arc and receives only thermal radiation. (In systems in which the specimen is immersed in an arc or plasma jet, it is subjected to aerodynamic and electromagnetic forces in a highly ionized medium.)

The arc is powered by a rectifier unit with a continuous rating of 500 kw, which corresponds to about 560 V at 900 amp. It is fed by a separate substation of a 13,800-V, three-phase primary transmission line. The permissible overloads are 2000 W for one minute and up to 9000 amp for 1.4 seconds. The silver anode-clamp and the compressed-air manifold and nozzles are water-cooled. The stainless steel cathode-clamp and the manifold are protected from the intense heat by graphite baffles whitened with silica flour. The position of the anode tip is maintained by a servo-controlled optical-electric-hydraulic system.

The extreme heating rates of the furnace melt or vaporize specimens so rapidly that a test may take as little as 0.2 seconds and seldom lasts longer than 10 seconds. Reliable testing under these conditions requires completely automatic control of the furnace and the test instrumentation. A sequence timing and control system in fact automatically programs all control and measurement functions to cover tests of 0.1 to 5.8 seconds. In the only manual operation that is required,





DISASSEMBLED specimen housing (above), with the rotating slit at the left. The clam-shell shutter is behind the quartz dome. A calorimeter is mounted in place of the specimen. Left: The complete specimen housing system with rotating-slit drive motor and belt. On the left is a slow shutter that supplements the clam-shell shutter inside the housing.

the arc is struck by remote control of the cathode carbon.

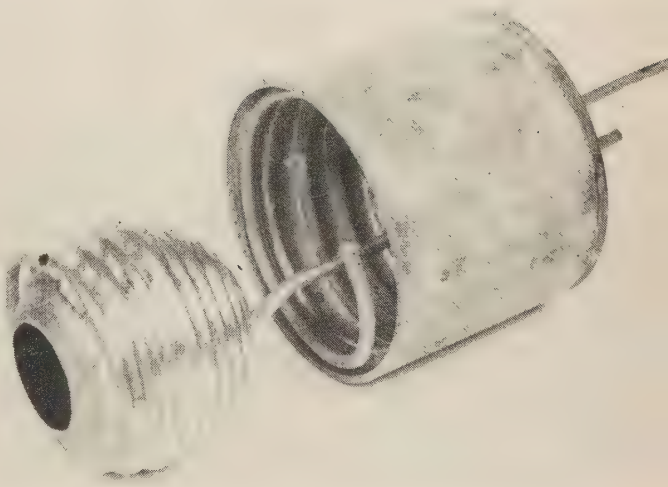
The automatic control can be bypassed when operation of the arc for long periods is required, as in studies of arc phenomena and arc reaction products or in material development studies. The arc can then be operated for several minutes at a time, depending upon the electrode consumption rate (which is a direct function of the arc current).

Shutter controls exposure

Specimens are mounted in a hermetic housing, with connections outside the furnace pressure vessel for pressurization or evacuation, and are irradiated through a hemispherical quartz dome. Immediately behind the dome is a solenoid-operated high-speed clamshell shutter for controlling the exposure of the specimen or of a calorimeter independently of the other controls.

The mirror system has a magnification of unity, and the diameter of the anode ball, or hotspot, is about ⅞ in. This limits the diameter of the specimen to ⅝ in. if uniform irradiation is required. Defocusing the specimen by moving it toward the arc-imaging mirror makes it possible to test specimens with larger diameters while maintaining nearly uniform irradiation, but the flux density falls off sharply.

A calorimeter can be substituted for the specimen in the housing for calibration of the thermal flux under



WATER-COOLED radiation receiver of the black-body calorimeter (removed from its radiation shield).

CARBON-ARC system with the water connections for the anode clamp and the adjusting mechanism of the cathode.

SPECIMENS of copper, stainless steel, and bakelite with thermocouples installed for the determination of dynamic thermal properties. The copper specimen has already been tested and shows the absorptive blackening partly burnt away and a certain amount of melting.

experimental conditions. A radiation-shielded, water-cooled black-body receiver, it has a ⅝-in. aperture with a useful entrance angle of 160 deg. Its diameter is 2¼ in. The water-cooled aperture plate is made of silver, and tantalum inserts surround the aperture.

The thermal flux is determined by measuring the inlet and outlet temperatures of water flowing at a known, constant rate through the receiver cooling coils. The receiver's absorptivity is about 0.98. The calibration of the calorimeter system as a whole has been checked both with a known electrical energy input and by water addition.

Optical system limits capacity

The capacity of the calorimeter is limited by the optical system to about 400 cal/sq cm/sec. A rotating-slit attenuator that cuts down the radiation entering the calorimeter to one-fifth of the incident radiation is used for measuring of higher fluxes.

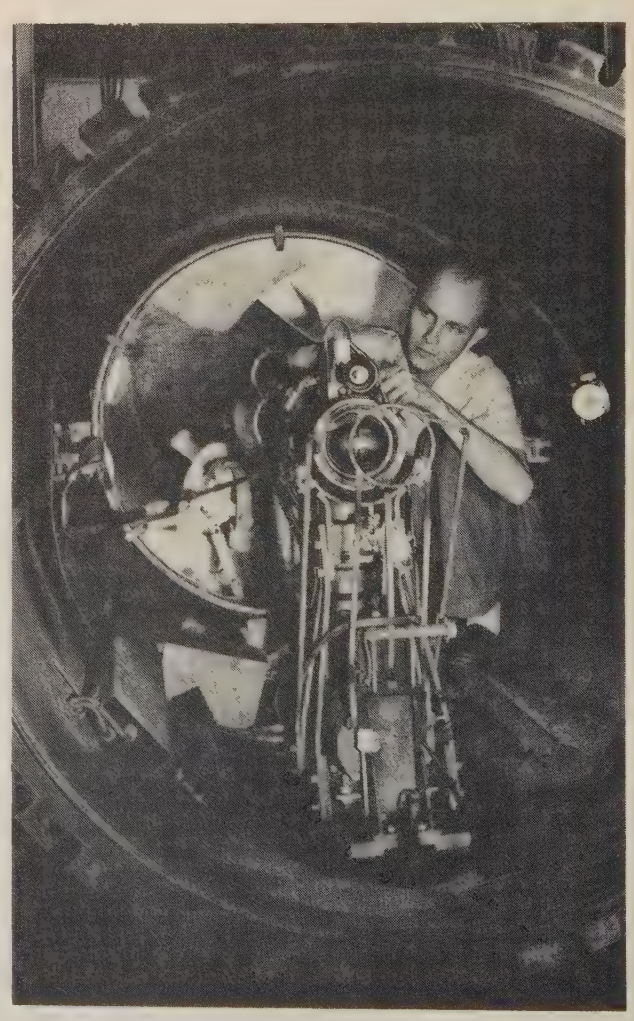
The thermal inertia of the calorimeter is too large for measuring rapid variations in thermal flux, and the integration process required for computation of the thermal flux only gives the average flux over a given time interval. A cadmium sulfide photoconductive cell is therefore used to observe short-term flux variations during calorimetric calibrations and to monitor the incident flux on a specimen during a test.

When detailed information on heat transfer into the specimen, thermophysical properties, or the dynamic values of thermodynamic quantities is required, temperature-time records are compiled for several locations along the axis of the specimen perpendicular to the irradiated surface. Calibrated thermocouples embedded in the specimen are used for this purpose.

In a typical test the specimen may range from ½ to ⅝ in. in diameter. It is surrounded by a 5-10-mil space usually filled with silica flour and then by a guard cylinder, or radiation shield made of the same material as the specimen. This shield is covered with asbestos, and the exposed ends of shield and specimen are normally blackened with acetylene soot to reduce the loss of incident energy by reflection. The galvanometric oscillograph record of the test might show arc current and voltage, tank and nozzle pressure, and time vs temperature for four thermocouples along the specimen axis.

The study of surface reactions and ablation and other high-temperature phenomena requires the recording of emission and absorption spectra during specimen irradiation. A quartz window in the furnace access door permits direct observation of the specimen. A standard radiation source and a mirror system allow observation of the area immediately in front of and parallel to the specimen, and a lens and mirror system outside the tank directs either the emitted radiation or the heat from the radiation source to a dual-grating spectrograph.

High-speed color photographs, made through the observation port at up to 4000 frames per second, provide a record of surface changes, ablation, arc-image stability, and vapor deposition.



PARTIALLY DISASSEMBLED specimen housing system mounted in the pressure vessel. The slow shutter and rotating slit have been removed. The CdS cell for monitoring the thermal flux is mounted above the housing.

Electric equipment

checked for space environment

by O. P. Steele III,
Group Leader, Advanced Reactor Development Dept., Compact Systems Div., Atomics International*

EVEN ASIDE from nuclear radiation, the electric accessory equipment of nuclear spacecraft power supplies will have to operate under an entirely new set of environmental conditions. In the three-kilowatt Snap 2 unit, the temperatures will range from 1000 to 1200 deg F, while in the 30-kw Snap 8 they will go up to 1300 deg F. The electric equipment will also be subjected to higher vacuums than you can produce on earth—from 10^{-9} mm Hg at 400 miles altitude to 10^{-13}

* Atomics International Div., North American Aviation, Inc., P. O. Box 309, Canoga Park, Calif. This is a condensation of a paper, "The Effect of High Temperature and Outer Space Vacuum on Electrical Equipment," given at the Aerospace Transportation Meeting of the American Institute of Electrical Engineers in Philadelphia last June.

IN BRIEF

As part of its work on nuclear power systems under the Snap program, Atomics International has run a series of tests to find bearing materials and an electrical insulation system that can take high temperatures under vacuum conditions. Twenty combinations of bearing materials were tested for both static and dynamic friction under vacuum at temperature levels of up to 1000 deg F, and a high-temperature insulation system for a 600-deg-F electric motor was tested for torque and resistance changes under the same conditions. The results showed that the insulation system as well as several of the bearing materials look promising for use in extreme space environments.

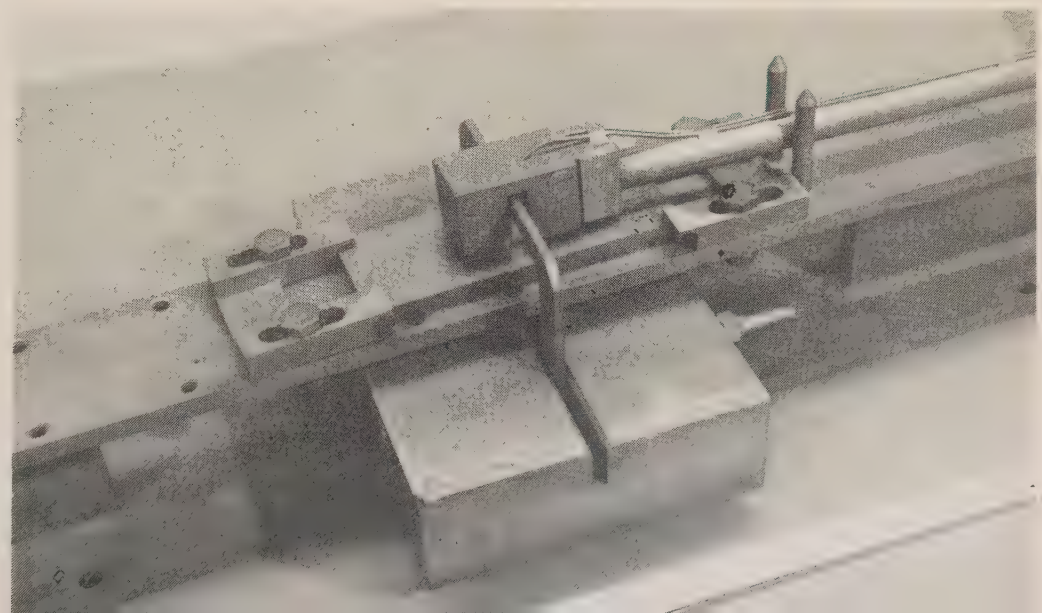


FIGURE 1: Bearing test fixture with the drive yoke in place over the Rider sample. The loading weight is suspended beneath the stationary sample table.

mm Hg or even less in outer space. Both temperature and vacuum conditions will have to be withstood with complete reliability over long operating lives—one year in the case of the Snap units.

At Atomics International we have been studying the effects of high temperature and vacuum on bearings and insulation. Various combinations of bearing materials have been tested in vacuums of up to 5×10^{-6} mm Hg and at temperatures as high as 1000 deg F. Our bearing test fixture was designed to impart a linear rather than a rotary motion to the test specimens (in order to transmit the motion into a vacuum chamber). This had the disadvantage that we could not check the actual bearing configurations, but it was adequate for screening materials.

In our test setup, two materials are always tested at the same time. One is clamped to the base anvil and the other is seated on top. The fixture is loaded by a dead weight suspended from a knife-edge beam. The sample is moved by a yoke driven by a force-ring transducer in the cool end of a furnace (*Fig. 1*).

Bearings used for reactor controls will be idle over 90 per cent of the time, so that the static as well as the dynamic coefficients of friction and any self-welding tendencies of the bearing materials are important. By feeding the output of the force transducer to a direct-writing high-speed recorder we were able to determine static and dynamic force, while self-welding was determined by weighing, inspection, and checking the surface finish after test.

The tests of the bearing material combinations started at room temperature and atmospheric pressure. A

Table I: Friction Coefficients of Bearing Materials[1]

Description	At Room Temp. & Pressure		After 10-20 hr @ 10^{-5} mm Hg & RT		After 24 hr @ 10^{-5} mm Hg & 600° F	
	Starting	Dynamic	Starting	Dynamic	Starting	Dynamic
WC (Kennametal K96) & TiC (Kentanium K162B)	0.22		0.65/0.53		0.68/0.55	
Haynes 25 & Haynes Stellite 3	0.63/0.40		0.61/0.46		0.82/0.61	
Cr_3C_2 (flame-sprayed on 316 SS) & Al_2O_3 (flame-sprayed on 316 SS)	0.18		0.63/0.55		0.49	
MoS_2 (electrofilm on 316 SS)	0.21		0.36		0.81[2]	
	0.20[2]					
MoS_2 (electrofilm on Inconel X)	0.32[2]					
MoS_2 (electrofilm on Haynes 25)	0.19[2]					
Al_2O_3 flame-sprayed on 316 SS) & TiC (Kentanium K162B)	0.22		0.33		0.34	
Graphite (Natl. Carbon CDJ-83) & Haynes 3	0.18		0.21		0.27	0.11
Hot-pressed Al_2O_3 (Norton LA 687) & SiC	0.51		0.88/0.79		0.69	
BN & Cr_3C_2 (Firth CR2)	0.37	0.23	0.39	0.37/0.30	0.53	0.42/0.33
WC (Kennametal K96) & SiC	0.50		0.42/0.25		0.79/0.71	
Hot-pressed Al_2O_3 (Norton LA 687) & graphite (Natl. Carbon CDJ-83)	0.19	0.27/0.21	0.30/0.22		0.13	0.05
Cr_3C_2 (flame-sprayed on 316 SS) & TiC (Kentanium K162B)	0.29		0.42/0.37		0.48	
Al_2O_3 (flame-sprayed on 316 SS) & Haynes Stellite 3	0.21		0.45/0.30		0.90/0.68[2]	
Al_2O_3 (flame-sprayed on 316 SS) & Haynes 90	0.16		0.16		0.31/0.26[4]	
Al_2O_3 (flame-sprayed on 316 SS) & Haynes 90	0.15		0.15		0.29/0.24	
Graphite (CDJ-83) & Haynes 90	0.20/0.17		0.22		0.19	0.10

(1) As ratios of maximum to average friction coefficients; where only one number is given, the maximum was within 0.05 of the average. (2) Test stopped because of active friction. (3) BN showed excessive wear. (4) Stopped because of equipment failure.

vacuum of 5×10^{-6} mm Hg was then pulled—with the chamber still at ambient temperature—while a continuous record was made of the changes in the coefficients of friction. Once the vacuum was established, the temperature was raised to 600 deg F and held for 24 hours. Every two hours, the sample was moved through two cycles and the coefficients were measured. The temperature then was raised by 100 deg F at 24-hour intervals until 1000 deg F was reached, while testing continued on a two-hour basis. The combination under test was then held at 1000 deg F and 5×10^{-6} mm Hg for seven days. Testing continued at two-hour intervals, except for 10 one-hour periods and one 16-hour period.

At the end of the seven days, the temperature was dropped to 600 deg F and an inert atmosphere was introduced into the chamber. These conditions were maintained for 24 hours, and then a final series of tests was run at ambient temperature and pressure.

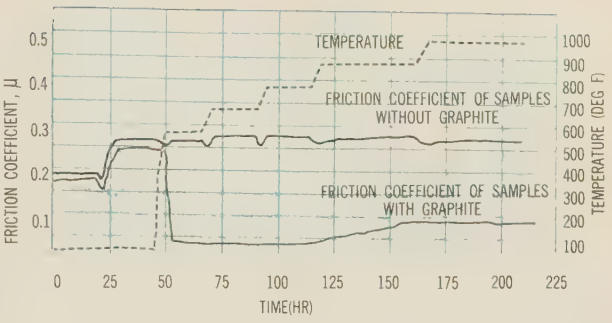


FIGURE 2: Friction coefficient of bearing materials. At 20 hours, a vacuum of 10^{-5} mm Hg was pulled.

After 24 hr @ 10^{-5} mm Hg & 1000°F		After 7 days @ 10^{-5} mm Hg & 1000° F		At Room Temp. & Pressure	
Starting	Dynamic	Starting	Dynamic	Starting	Dynamic
0.64/0.48		0.78/0.53		0.71/0.50	
0.94/0.65		0.63/0.45		0.71	
0.43/0.33		0.37		0.65	
0.25		0.39		0.89/0.74	
0.21	0.11	0.47	0.24	0.29	0.21
0.45/0.23		0.57/0.27		0.95/0.74	
0.55	0.40	0.66	0.47/0.40	0.23[3]	
0.57		0.54		0.47/0.38	
0.23	0.20/0.12	0.09		0.22	
0.53	0.39	0.63	0.43	0.74	
				0.85/0.75	
				0.75/0.66	
0.05		0.18		0.17	

Tables I & II show the results of our bearing materials tests. All test samples had a surface finish of eight microinches or better before testing and were run dry. (A dry-film lubricant was tested on Haynes Stellite 3 and on stainless steel. Both these materials then failed before the full test conditions had been reached and the coefficient or friction could have been measured.)

Results show short-term drop

The test results show a definite short-term drop and subsequent rise in the coefficient of friction of the time when vacuum was pulled at room temperature (*Fig. 2*). We attribute this effect to the outgassing of a thin gas film from the material that provides a lubricating surface under atmospheric conditions. This explanation is substantiated by the momentary friction reductions that occurred with temperature increases.

The results for the samples that included graphite differed markedly from those for the other materials combinations. The graphite used in our tests was developed for high-altitude airplane brushes and had the moisture content that normally gives graphite its lubricating effect replaced by an additive. The low coefficient of friction of the graphite combinations was probably caused by slow, continuous outgassing of this additive (to provide a lubricating effect). Our tests were not, however, extensive enough either to establish this effect beyond doubt or to determine how long it might continue.

The samples containing no graphite showed a temporary drop in friction at each temperature increase, similar to the drop when the vacuum was first pulled. Increased outgassing of the samples provided temporary additional lubrication in these cases. The stabilized friction level did not change appreciably up to 1000 deg F.

Aluminum oxide gave best results

The best results were given by hot-pressed aluminum oxide on graphite. Neither the static nor the dynamic coefficient of friction of this combination exceeded 0.30 during the entire test series. Other low-friction combinations were flame-sprayed aluminum oxide and titanium carbide, and graphite and Haynes Stellite 3.

There was negligible change in the surface finish, weight, and/or dimensions of the combinations giving

Table II: Physical Data on Bearing Materials

Material	RMS Surface Roughness (uin.)		Weight Change (gm)	Dimensional Wear (in.)
	Before	After		
WC (Kennametal K96)	6		*	0.0000
TiC (Kentanium K162B)	6	25		
Haynes 25				
Haynes 3	4	9	−0.00180	0.0000
Cr_3C_2 (flame-sprayed on 316 SS)	2	5		
Al_2O_3 (flame-sprayed on 316 SS)	1.5			
Al_2O_3 (flame-sprayed on 316 SS)	1.5	1.3	−0.00121	0.0000
TiC (Kentanium K162B)	6	6	*	0.0001
Graphite (Natl. Carbon CDJ-83)	150	80	+0.00018	0.0004
Haynes Stellite 3	4	9	−0.00080	0.0000
Hot-pressed Al_2O_3	3	8	0.00000	0.0000
SiC	4	4	*	0.0000
BN	30	80	−0.11724	0.0092
Cr_3C_2 (Firth CR2)	8	10	*	
WC (Kennametal K96)	5	2.5	−0.00078	0.0000
SiC	7	5	*	0.0001
Hot-pressed Al_2O_3 (Norton LA-687)	4	2	+0.00015	0.0000
Graphite (Natl. Carbon CDJ-83)	10		*	0.0004
Cr_3C_2 (flame-sprayed on 316 SS)	2	2.5	−0.00008	0.0000
TiC (Kentanium K162B)	5	5.5	+0.00080	0.0000

*Hold-down clamps chipped corners on the samples, so that weight change due to wear could not be isolated.

Table III: Test Motor Characteristics

	Before testing	Initially	After 1750 hr at 1000 deg F & 5×10^{-5} mm Hg
Phase voltage (V)	117	117	117
Phase current (amp)			
No. 1	20.2	17.45	18.05
No. 2	23.8	20.5	20.6
No. 3	19.8	16.75	16.9
Power (W)	2050	3880	3880
Torque (in.-oz)	162	165	165
Phase resistance (ohms)	0.9	2.35	2.35
Insulation resistance (megohms)	15+	1	1

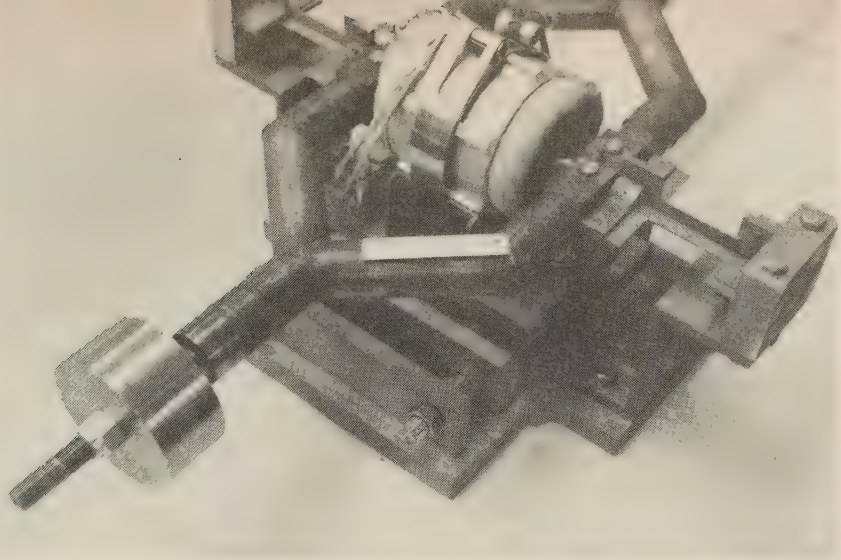


FIGURE 3: High-temperature motor mounted in test fixture with balance torque arm in place.

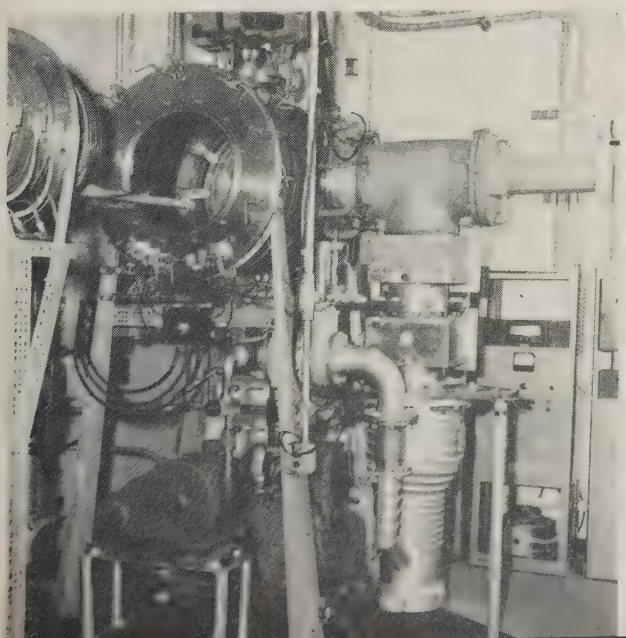
the best performance. These results may, however, be misleading (especially in evaluating the effects of self-welding), since our tests were made in a comparatively poor vacuum not hard enough to create or maintain a really clean surface.

To check the effects of high temperature and vacuum on electric insulation, we used a Westinghouse motor that had been successfully tested at 500 deg C under atmospheric pressure. While this motor does not have the characteristics that would be required for reactor control, its insulation scheme could be used in a motor designed for this application.*

The magnetic material used in the motor is high-silicon steel laminations. The squirrel-cage winding is silver, with silver-brazed end rings. The stator windings are alloy-clad copper with a bonded frit insulation. For slot and phase insulation a Westinghouse high-temperature laminated mica-glass fabric with ceramic slot wedges is used.

* J. G. Hopp, D. K. McIlvaine, "New Materials for Transformer Rectifier Units, High Temperature Aircraft;" AIEE Paper 5983.

HIGH-VACUUM cold-wall test chamber used at Atomics International. The vacuum system combines an oil diffusion pump, a liquid hydrogen pump, and a getter ion pump. The test specimen is heated by quartz infrared lamps.



The winding ends are welded to solid-silver terminals mounted on inorganic, bonded mica-glass composition terminal boards. These in turn are potted in a Westinghouse compound consisting of a mixture of refractory oxides and glass frits. The potting material is applied to the motor by vacuum impregnation in the form of a slurry, the potting over the end portion is shaped, and the unit is then dried and fired at 600 deg C. The surface is glazed with fused glass frits for increased mechanical and moisture protection. The external ferrous surfaces are protected against oxidation by a coating of heat-resistant aluminum paint.

Motor insulation was checked

We built a special test fixture to check the insulation of this motor independently of the bearings (*Fig. 3*). The stator is solidly clamped to the fixture base, and the rotor is mounted on thin, perpendicular beams that hold it rigidly centered in the stator but allow rotation through small arcs, for which the beams absorb less than two per cent of the motor torque. A balanced torque arm is rigidly fastened to the rotor end extensions and to the cool end of the vacuum test chamber.

The motor was tested under a locked-rotor condition, since we felt that this type of cycling would produce the severest insulation stress and closely simulate the start-stop cycling of the reactor control operation. During the tests, the motor was held at 1000 deg F in a 5×10^{-5}-mm-Hg vacuum. The full voltage was applied every hour for two seconds, and voltage, current, power, and output torque were measured. The insulation resistance to ground was measured every 24 hours with a 250-V megohmer insulation tester.

As *Table III* shows, there was no measurable degradation in either insulation resistance to ground or torque characteristics after the initial change from room temperature to the test conditions. These results of the motor tests look encouraging, but there were two side effects that should be kept in mind in their evaluation:

- The pumping rate and the ultimate vacuum in the test chamber indicate that there was a continuous gas load above what we had expected for the bare chamber. Apparently there was a continuous outgassing of the motor insulation that was not reflected in any performance change.
- At the end of the tests, we found a small amount of material had been deposited on the chamber wall at the cool end.

men at work on a new approach to the stars

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No. 21 on Reader Service Card

Conveyorized grinding

holds close honeycomb tolerances

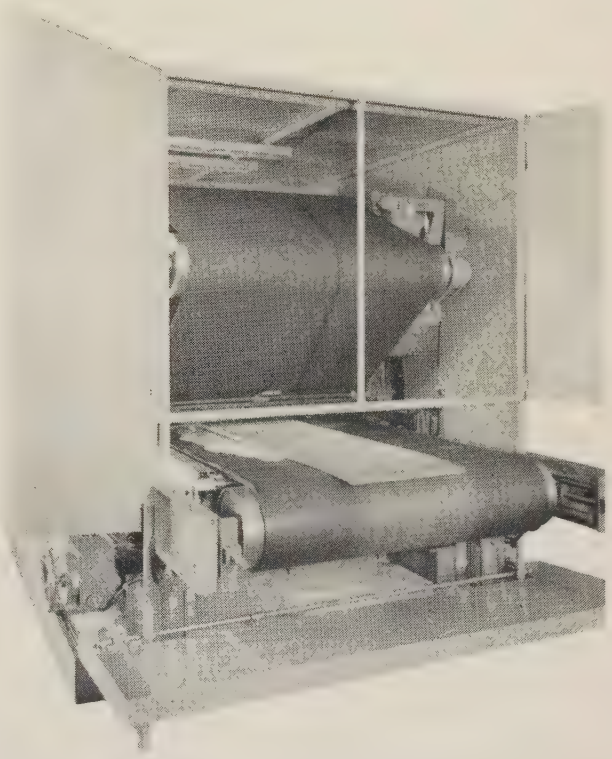
by L. G. Brown,
Engineer, Mattison Machine Works*

CONVEYORIZED wide-belt grinders provide a new, fast way to grind honeycomb cores and stainless sheets to thickness tolerances of ± —0.001 in. These grinders cover up to 72-in. widths in one pass with precise dimensional control, as has been proven on materials for the B-70, slashing man-hours required for honeycomb grinding, polishing and work-handling operations.

Two types of wide-belt grinders—a conveyorized machine to finish honeycomb and sheet stock, and a pinch-roll grinder for stainless sheet, plate, and strip—are made by Mattison. Though each grinder is designed for its own job, both operate on the same principle and both reduce finishing cost in proportion to their full belt widths.

Each grinder gets positive grain penetration through a combination of diamond-shaped head design and belt-drive power of up to 150 hp. Four rollers in the head continuously flex the abrasive belt to keep it clean, cool, and free-cutting, and to avoid wrapping of a belt on the contact roll. The resulting flat angle of abrasive contact lets the belt conform more closely to uneven surfaces of the honeycomb blanket or steel sheet.

Each roller has a special function. One aligns the belt, one drives it, and another supplies grinding pressure. The fourth is an idler that provides additional



HONEYCOMB SECTION feeds into conveyorized grinder. Opened doors show diamond shaped grinding head's idler roll.

* Mattison Machine Works, Rockford, Ill.

IN BRIEF

Close tolerance control, as the B-70 program points up, is a must for efficient, minimum-weight honeycomb structure. Advanced vehicle designs require grinding of face sheet and core sections to tolerances on the order of ±0.001 in. To cut costs as much as possible, special grinding equipment has been developed.

Mattison Machine Works has designed two conveyorized, wide-belt grinders that cover 72-in. sheet or core widths in one pass while still providing precise dimensional control. Their advantages are said to include low initial cost, fast stock removal, and quicker grinding, polishing, and parts handling.

In conjunction with this type of grinder, a batch processing method is used by honeycomb manufacturers for maximum production efficiency.

He's solving a real estate problem

This AMF engineer's job is deter-
mining how best to move big missiles
off shore for launching. Should they
be floated out horizontally, flooded
to an upright position, and then
launched? Or, would it be more fea-
sible to barge them out? Might they
be moved to or assembled on "Texas
Towers," or would a causeway or
simply land-fill be the answer?

Behind the project is our shrinking
real estate at launching sites, plus the
hazards inherent in launching Sat-
urn-sized missiles (and the coming
nuclear-powered missiles) near other
installations. Off-shore launching
may be the answer.

Feasibility studies of all types are
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remotely controlled machinery is
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aircraft? What kind of habitation
could be built on (or under) the sur-
face of the moon? What sort of
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are problems AMF engineers are
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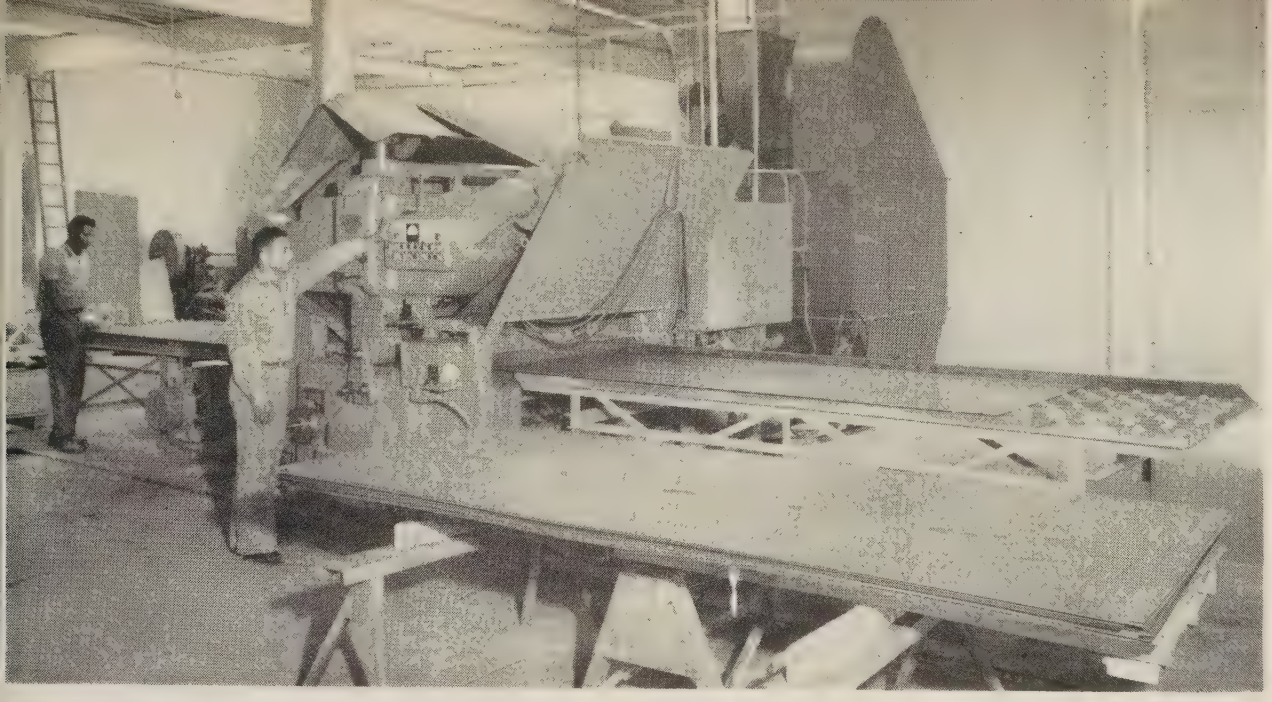


BATCH-FEEDING of stainless sheet and honeycomb provides maximum grinding efficiency. Pinch-roll grinder uses cutting oil spray for sizing stainless sheets.

belt flexing to prevent loading and to increase stock removal per square inch of abrasive belt.

The drive roll for the 20-ft, three-inch abrasive belts is located left of the contact roll and pulls the clockwise-rotating abrasive belt through the grind point under constant tension. This permits positive control of abrasive grain penetration and minimizes belt flexing at the grind point. Separation of the contact and drive functions also prevents transfer of motor pulsations to the work, thus permitting fine finishes.

Grinding principles are simple

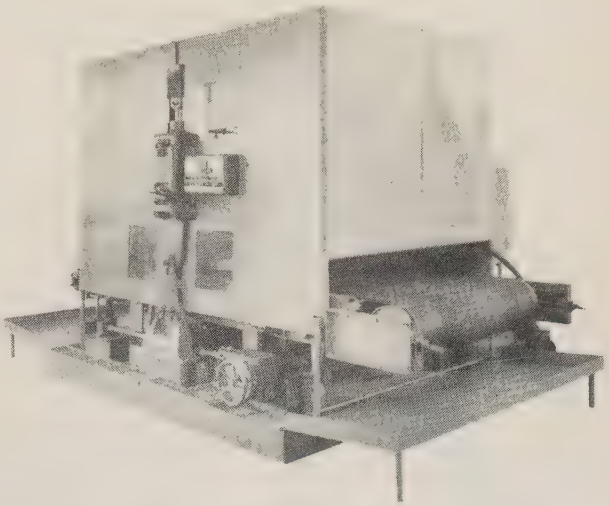
The principles involved in precision flat sheet grinding are quite simple. A rolled or stretcher-leveled sheet always has a slight crown and several high, or thicker, areas. If stock is fed slowly into a pinch roll feed-type grinder, the neoprene contact roll tends to conform and to grind all sections somewhat, depending on the grind pressure. For best sizing, therefore, sheets must be run through at higher speeds with low grind pressures, until all high spots are removed, with little or no grinding in the lower areas. When each sheet is of near constant thickness, the rate of stock removal may be increased to size the sheet to just above final gage. After sizing, a fine-grit belt quickly reduces any roughness to final microinch requirements and exact final gage.

Honeycomb grinding methods vary somewhat, depending on material parameters. Honeycomb cell walls, for instance, can vary from thicknesses of a few tenths to 0.002 in. Cell walls must not be bent over during the first passes, to minimize burring and because out-of-flat conditions might cause high spots which would become thin sections after grinding.

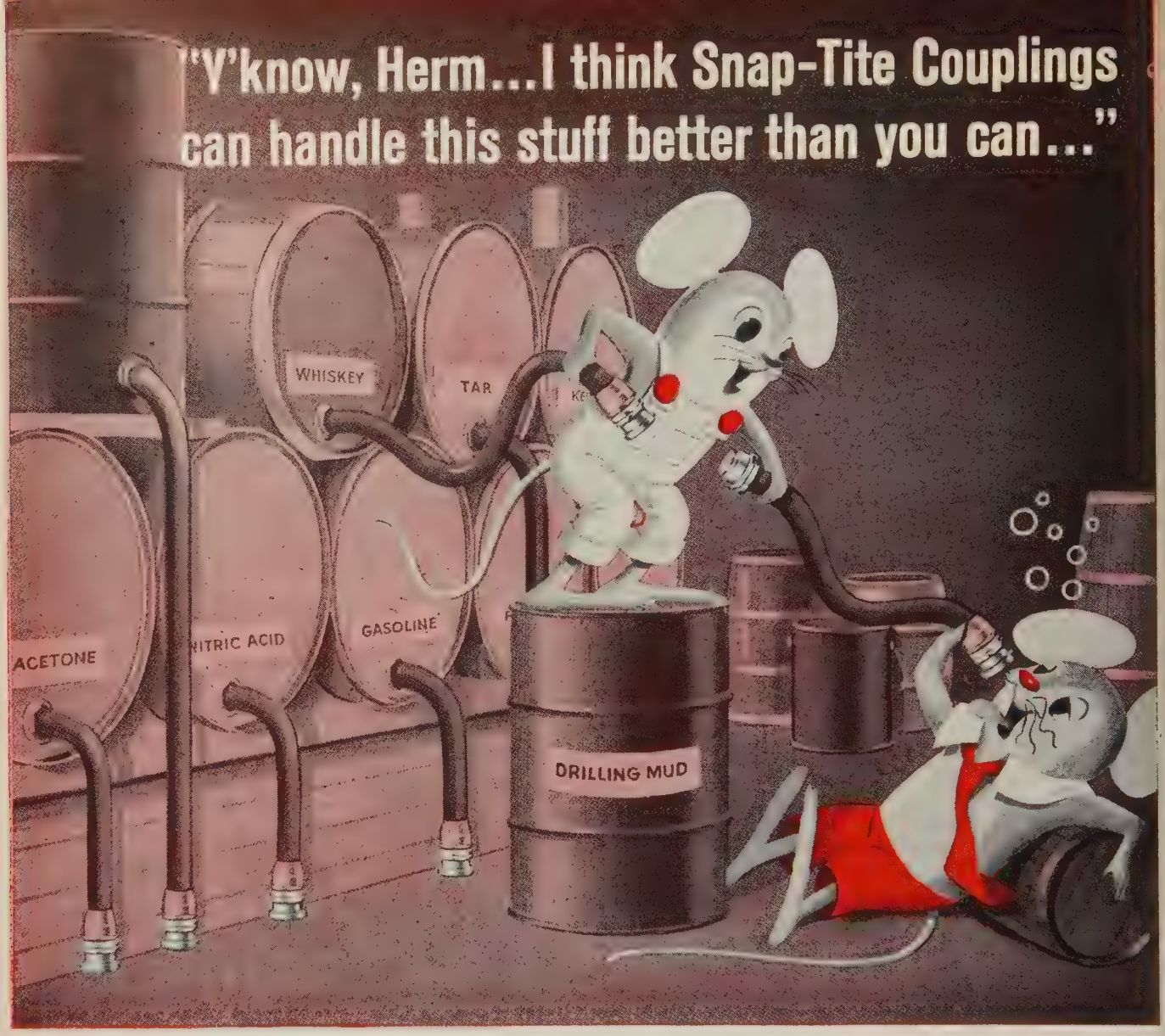
A new Mattison conveyorized grinder avoids these problems by counterbalancing the conveyor table at each corner with air cylinders. Thus, grinding pressure is equalized across the entire belt-width and the contact roll can't exert excessive pressure on the material.

Flat work is carried up to the contact area on a 36-, 48-, 60-, or 72-in. rubber conveyor supported by rollers and traveling at speeds from 6-60 fpm. There's no pitch limitation to the work, because the machine has no pinch rolls. The table is fed into the contact roll by six precision screws, synchronized from a common drive for absolute parallelism in both directions. Rapid up-and-down table traverse can be controlled by push-button or handwheel. Automatic upfeed increments from 0.0002 to 0.005 in. per impulse compensate for belt wear or piecepart size. Gaging and depth setting are manual.

To prepare a honeycomb core or blanket, a heated



CONVEYORIZED grinder developed by Mattison has 72-in. wide abrasive belt area. Table is counterbalanced at each corner with air cylinders to equalize grinding pressure across entire belt width.



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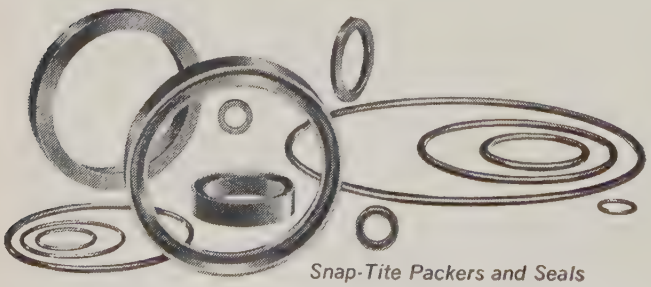
To assist you in the proper selection of coupling seal material, Snap-Tite, with the assistance of suppliers of synthetic rubber materials, has recently compiled a comprehensive Packer Usage Guide —the first of its kind in the industry.

For the Packer Usage Guide, and for complete information on the correct choice of quick-connect, quick-disconnect couplings for the fluids *you* use, write Snap-Tite, Inc., Union City, Pa.



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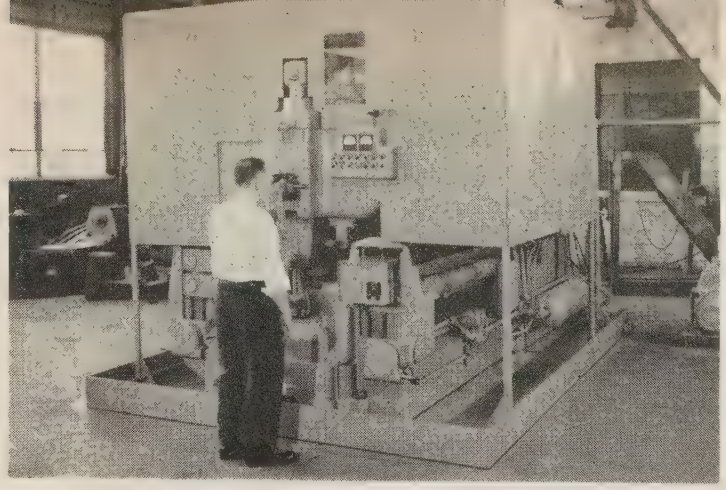

PINCH-ROLL feed abrasive belt grinder is equipped for flooding water-soluble coolant during grinding. Machine finishes PH15-7Mo to ±0.001 in. It also can be used to grind copper sheets for honeycomb brazing assembly.

mixture of beeswax and rosin is poured into the last three or four end cells across the blanket to prevent cell layover during grinding. When the wax has cooled, excess is removed flush with the top of the cells. The rest of the core requires no attention.

Thickness determines abrasive belt

Cell-wall thickness determines the selection of the abrasive belt and amount of stock to be removed. Thin cell walls (up to 0.0015 in.) require 320G or 240G aluminum oxide abrasive belts and light cuts of only 0.001 to 0.002 in. per pass. Silicon carbide type belts are also acceptable. Heavier cell walls (over 0.0015 in.) require 180G aluminum oxide abrasive belts. Cuts of 0.003 to 0.005 in. pass are possible.

Subcontractors who grind honeycomb cores for the B-70 program are getting greatest efficiency from conveyorized grinders with a batch-type processing method. All cores are run consecutively, thickest cores first, to avoid bending of cell walls. The entire batch is piled on a truck, with interleaved separator sheets. On completion of each run, cores can be trucked to the feed end, inverted, and run through again.

Conveyor speed of 32 fpm is best for nearly all work. Stock is fed in the same direction as the abrasive belt rotates. Cores are reversed after each pass in order to continually flex the ground edge of the cell and aid burr break-off.

Core turned every second pass

When a new core is started, it is inverted every second pass until one side is completely cleaned and flat. Thereafter, stock can be removed from one side until the core is within 0.002 in. of required thickness. At this point, no further upfeed is necessary. Two or three passes at set height allow the work to be "sparked out" and the final thickness will be within ±0.001 in tolerance on 60-in. widths and ±0.0015 in. for stock up to 72 in. wide.

Batch-type production on pinch-roll grinders also is recommended for most efficient sizing of stainless. This method has proved economical for finishing PH15-7Mo to ±0.001 in. It also may be used for grinding copper sheets used in sandwich brazing assembly. Grinding procedure is similar to that for honeycomb—several light cuts at higher feed rates are preferred for taking off higher or thicker areas with a minimum of grinding on thinner areas.

Assuming a batch of 10 sheets, it is best to take three or four Vidigage readings on each sheet to pick out the heavier ones. The grinder is set up with a 50G aluminum oxide belt to remove about 0.005 in. of stock on the heavier sheets. All sheets are run consecutively, thickest sheets first, and stacked on the outfeed side of the grinder.

Sheets are run through for six or eight passes at about 25 fpm without changing the billy roll setting. Then the billy roll is raised another 0.005 in. and the procedure is repeated. Sheets are turned end for end and inverted on every other pass to equalize thickness and eliminate off-tolerance.

On the first few passes, grinding contact shows only on the high spots. Subsequent passes begin to show an overall grind pattern. When all sheets show complete area grinding, each is checked by Vidigage at edges, ends, and center to assure uniform thickness. If high parts are indicated, grinding is repeated until all sheets begin to show acceptable tolerances. Heavier cuts can now be taken with periodic checks until all sheets come within about 0.001 in. of maximum required gage. At this point, a 120G silicon carbide belt is placed on the grinder. Two passes on each side of a sheet usually completes it to the 32-uin. or better finish.

Stops regulate billy-roll position

A special stabilized air control on the billy roll guarantees constant grind pressure throughout the length of a sheet. Positive adjustable stops regulate the level position of the billy roll under pneumatic grind pressure. These stops are manually controlled and indicated by a dial with 0.001-in. graduations.

Grinding contact is made within only ¼ in. of a sheet's lead end. A photoelectric cell senses the leading edge as the sheet enters the feed rolls. The electric eye pickup actuates a control mechanism which raises the billy roll and brings the sheet into contact with the abrasive belt. Uniform grinding pressure is maintained to within ¼ in. of the sheet's trailing edge. This design permits optimum grinding contact but prevents either end of a sheet from cutting into the abrasive belt and making a mark that would be transferred when grinding the next sheet.

Both grinding machines operate with greatest precision when water-soluble grinding fluids are used. Proper cooling during grinding gives about twice the control of tolerance.

These grinders cost less initially than table-type wide-belt grinders because accurate shaping of ways and table aren't needed. Construction of these parts alone sometimes costs as much as, or more than, the motorized grinding heads. Write in number 58 on Reader Service Card for more information.

Insulation news from Johns-Manville

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JM

No. 24 on Reader Service Card

by M. L. Torti, Director, Metallurgical Research, Metals Div., National Research Corp*

90Ta-10W offers high temperature strength **plus** ductility

RESEARCH on refractory metals has yielded an alloy of exceptional promise for high-temperature applications: 90 per cent tantalum-10 per cent tungsten, now commercially available in a number of forms. Metallurgists working with this material expect that even better other alloys will ultimately be developed from it.

The new alloy approaches the strength of pure tungsten at high temperatures but retains much of pure tantalum's exceptional ductility and workability at room temperature. In sheet form, the alloy is about twice as strong as pure tantalum at room temperature. Elongations are almost as high as those of pure tantalum, resulting in a material easily formed with conventional metal-working equipment at normal temperatures. The impact resistance is better than that of almost any known material (including the austenitic steels). The ductile-to-brittle transition temperature is exceptionally low—close to —320 deg F—compared with that of high-strength columbium-, tungsten-, and molybdenum-base alloys, which is at several hundred degrees above zero.

The oxidation resistance of 90Ta-10W is better than that of pure tantalum. For extended service above 750 deg F under oxidizing conditions, a protective

Physical and Chemical Properties of Arc- or Electron-Beam-Melted 90Ta-10W

Typical Impurity Analysis (ppm)	
O	40
C	25
N	15
Fe	10
Cr	5
Ni	5

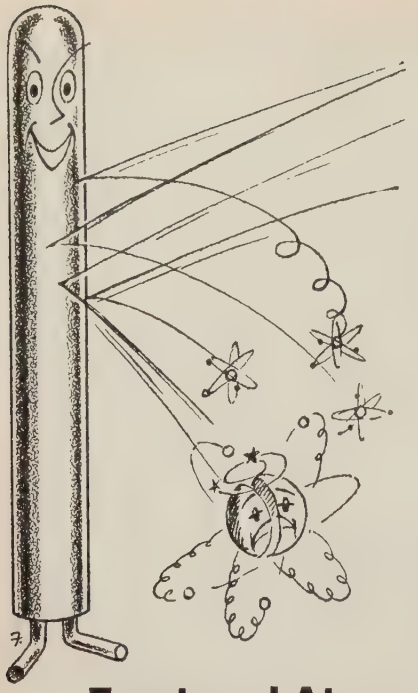
Physical Properties	
Annealed (60-mil sheet)	
Yield strength (psi)	83,600
UTS (psi)	90,000
Elongation (per cent)	28
Cold-rolled	
Yield strength (psi)	164,000
UTS (psi)	180,000
Elongation (per cent)	4

* Metals Div., National Research Corp., Cambridge, Mass. Much of the data presented here was gathered under BuWeps sponsorship.

IN BRIEF

The great amount of research devoted to the refractory metals gives an idea of the great promise held by these materials for solving extreme-environment problems. Because of the difficulties posed by the physical and fabricating properties of the pure metals, this research naturally has led to intensive alloying studies.

One of the most hopeful results of these studies is the 90Ta-10W alloy. Already available in commercial forms from several sources, it offers a combination of good fabricability by more-or-less conventional methods and good high-temperature strength. This report on 90Ta-10W gives preliminary design information, reviews a number of actual and potential applications, and gives data on machining, forming, drilling and threading.



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Physical Properties of 90Ta-10W[1]

Melting point	5520 ± 30 deg F
Electric resistivity[2]	17.4 microhm-cm
Density	0.609 lb/cu in.
Crystal structure	body-centered cubic
Lattice spacing[2]	3.282 A
Modulus of elasticity at room temperature)	28-30 × 10^6 psi
Spectral emissivity (1600-2700 deg K at 0.065 microns)[3]	0.347
Total emissivity (1600-2700 deg K)[3]	0.328
Thermal Conductivity[3]	
At 1800 deg K	0.131 cal/cm^{-1}/deg K^{-1}/sec^{-1}
At 2000 deg K	0.124 cal/cm^{-1}/deg K^{-1}/sec^{-1}
At 2400 deg K	0.110 cal/cm^{-1}/deg K^{-1}/sec^{-1}
At 2800 deg K	0.096 cal/cm^{-1}/deg K^{-1}/sec^{-1}
At 3200 deg K	0.082 cal/cm^{-1}/deg K^{-1}/sec^{-1}
Thermal expansion from room temperature (ΔL/L)	
To 1000 deg C	0.0054
To 1200 deg C	0.007
To 1600 deg C	0.0108
To 2000 deg C	0.0148
To 2400 deg C	0.0192
To 2800 deg C	0.0218
Specific heat (at room temperature)	0.35 cal/gm/deg C

(1) Preliminary data for 60-mil cold-rolled sheet. (2) From R. H. Myers, Metallurgia, 42, June '50. (3) From Aerojet-General.

coating or cladding is required.

A number of special applications for the new alloy have already developed, and others are under consideration:

- aerodynamic structures at over 2500 deg F, for which 90Ta-10W offers the highest strength-weight ratio as well as easy fabricability;
- lightweight solid and advanced liquid rocket nozzles made from sheet stock for both propellant designs, for which 90Ta-10W offers excellent corrosion and erosion resistance in exhausts at temperatures beyond 6000 deg F and formability for spun, drawn, and welded shapes;
- heating elements for vacuum furnaces for sintering, annealing, and small-scale melting operations, for which 90Ta-10W offers better resistance to sagging and distortion at high temperatures than do pure tantalum elements, and (because of its ductility) longer life than tungsten or molybdenum elements;
- small parts (e.g., electronic tube components for springs which must be elastic at high temperatures) because of 90Ta-10W's retention of elastic properties at high temperatures and its great advantage in fabricability over pure tungsten;
- some experimental nuclear-re-

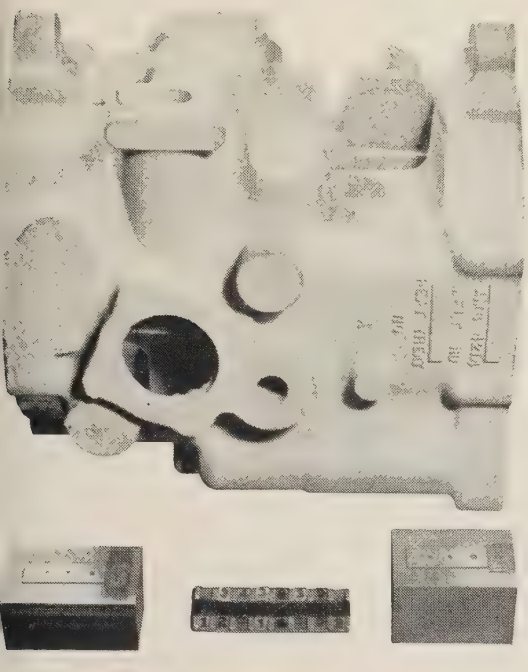
Room-Temperature Mechanical Properties of 90Ta-10W Sheet*

Gage (in.)	Condition	0.2% Yield Strength (psi)	UTS (psi)	Elongation (in 2 In., per cent)
0.060	cold-worked (95%)	164,000	180,050	4
	annealed (1500° C), ASTM #8 grain size	83,500	90,300	28.5
	annealed (1500° C), welded	84,100	95,000	27.5
0.010	annealed (1500° C), ASTM #8 grain size	75,000	88,700	19

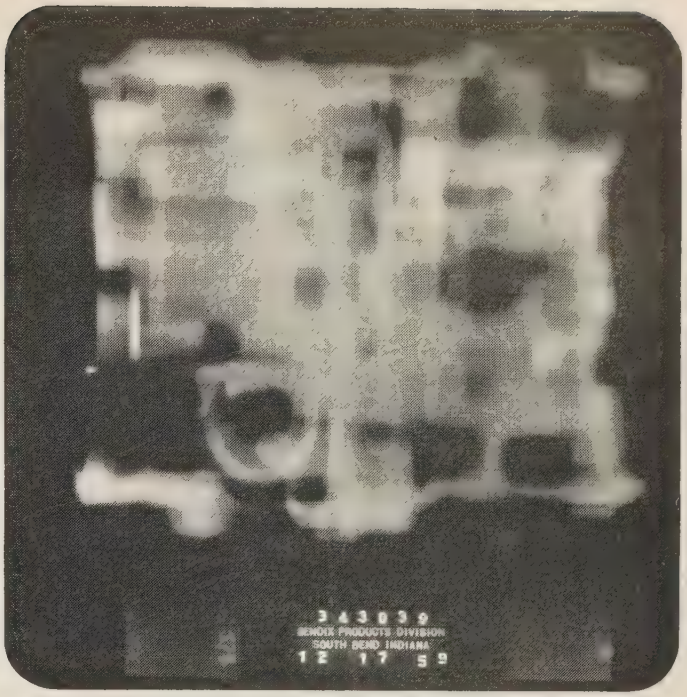
*Preliminary data.

ITS JOB:

Watching the diet of hungry jets



Casting for jet engine fuel control valve made by Bendix Products Division, South Bend, Indiana.



Radiograph of casting showing soundness and condition of internal passages.

A maze of passages and channels, this intricate casting becomes a jet fuel control valve. Bendix checks the soundness of the body and clearness of the passages with Kodak Industrial X-ray Film.

FEEDING 2500 gallons of fuel an hour with precise control is the task for this casting. It will be machined to infinitesimal tolerances and then precision fitted with valves and controls. Is the casting sound? Are wall thicknesses correct? Are internal passages clear? Bendix Products Division, South Bend, Indiana makes sure with radiography.

Radiography is the one means of non-destructive testing that not only inspects internal conditions but provides a record of the findings.

Producers of castings and makers of welded products use radiography to make sure that only quality work is delivered—a means of building a good reputation and increasing business.

Radiography may be important in your work, too. Why not discuss it with an x-ray dealer—or write us for a Kodak Technical Representative to call?

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Short-Time Tensile Properties of 90Ta-10W at High Temperatures[1]

Temperature (deg F)	0.2% Yield Strength (psi)	UTS (psi)	Modulus of Elasticity[2]	Elongation (in 1 In., per cent)
Room	160,500	116,500	20.6×10^6	9.0
1500	97,800	103,200	10.6×10^6	11.0
2500	19,850	22,250	8.6×10^6	22.0
	44,000[3]	58,000[3]		3.3[3]
	39,800[4]	41,700[4]		11.3[4]
3000	11,800	12,100	9.3×10^6	33.0
	15,100[3]	25,400[3]		13.1[3]
	9,800[4]	14,000[4]		41.84
3500	7,260	7,480	7.9×10^6	37.0
	11,300[3]	16,000[3]		24.3[3]
	2,500[4]	9,400[4]		46.64
4000	4,300	4,350	5.8×10^6	35.0
4500	2,060	2,060	2.5×10^6	30.0[5]
	3,500[3]	7,500[3]		14.4[3]
5000	645	645	0.8×10^6	20.0[5]

(1) Preliminary data; unless otherwise noted, from Southern Research Institute for a nominal strain rate of 0.01 in./in./min and ingots analyzed at 45 ppm oxygen, 15 ppm nitrogen, and 27 ppm carbon. (2) Strain measured from specimen grips. The modulus values are low, and that the strain values at the higher temperatures are questionable. (3) From Aerojet-General for a very high constant loading rate, a strain rate of about 1.8 in./in./min, and ingots analyzed at 50 ppm oxygen, 30 ppm nitrogen, and 27 ppm carbon. (4) From "Investigation of the Properties of Tungsten and Its Alloys," WADD TR 60-144, for swaged, arc-melted tungsten at a strain rate of 00.2 in./in./min. (5) Melted at the fracture point.

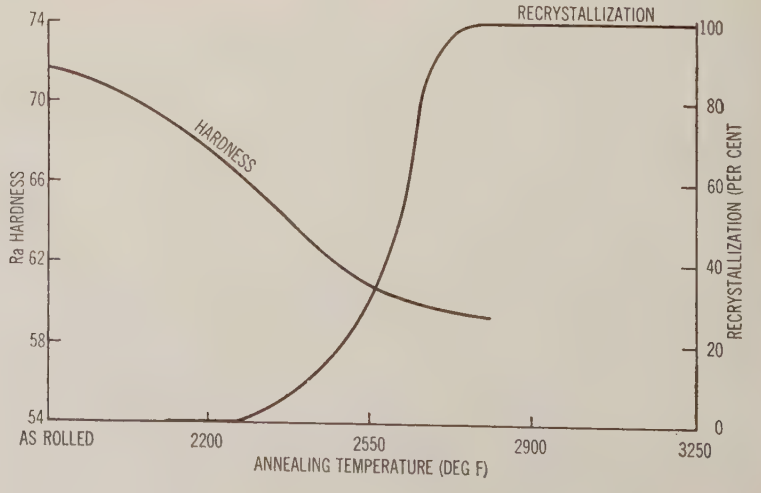
actor applications involving liquid-metal fuels and coolants, and very-high-temperature, inert-gas-cooled reactors, for both of which 90Ta-10W offers high strength and better corrosion resistance than does pure tantalum.

For any current application of tungsten and molybdenum, in general it would seem wise to consider 90Ta-10W as a replacement because of its fabrication advantages. In particular, 90Ta-10W offers advantages for tantalum applications requiring high temperature resistance, strength, or stiffness.

As the properties of the 90Ta-10W are affected by interstitial impurities, reasonable care must be taken to insure ingots of good purity. At NRC, double-vacuum-arc melting of high-purity mixed powders or electron beam followed by arc melting has given excellent results.

For 80 per cent or more cold work, 30 minutes' annealing in vacuum at 2750 deg F is generally recommended. This yields a fully recrystallized structure of about ASTM #8 grain size. For 40-80 per cent cold work, the tempera-

RECRYSTALLIZATION behavior vs temperature of 30-minute anneal for 90Ta-10W cold-rolled to 60-mil sheet with 95 per cent area reduction. Analysis of the material showed 0.0045 per cent oxygen, 0.0010 per cent carbon, 0.0015 per cent nitrogen, and 0.0030 per cent iron.



EW WESTINGHOUSE AIRBORNE COMPUTER ERFORMS 400,000 OPERATIONS...IN LESS ME THAN YOU CAN WRITE THE NUMBER

one second, a Westinghouse ital data processing system v being developed can perform ,000 complete operations, in- ding memory access. This sys- is the WDP-400, newest, test, and most versatile mem- of the computer family at stinghouse.

sed on the fully-proved WDP- — fastest airborne computer peration — the new WDP-400 upies less than 4 cubic feet, luding power supply and input tput unit. It can remember re than 7000 words, or more n 147,000 binary digits.

random access instruction mory is made of multi-aperture ite cores. Readout is non- tructive. Stored data is non- atile, and can be altered elec- ally without rewiring. These que capabilities add greatly to system's speed, versatility reliability.

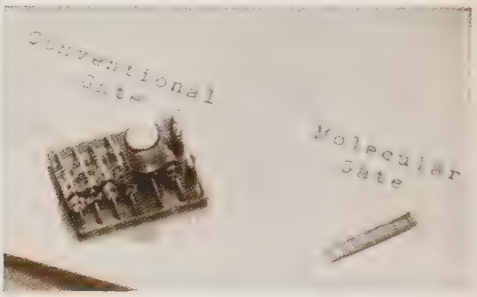
The WDP-400 and a variety of other advanced data processing systems—both large and small and with conventional and molecularized circuitry—are being built by Westinghouse Air Arm division to meet the most demanding and sophisticated defense and space requirements. For more detailed information write for the "System Computers" brochure.—Defense Products Group, 1000 Connecticut Ave., N.W., Washington 6, D. C. *You can be sure . . . if it's Westinghouse.*

J-01335

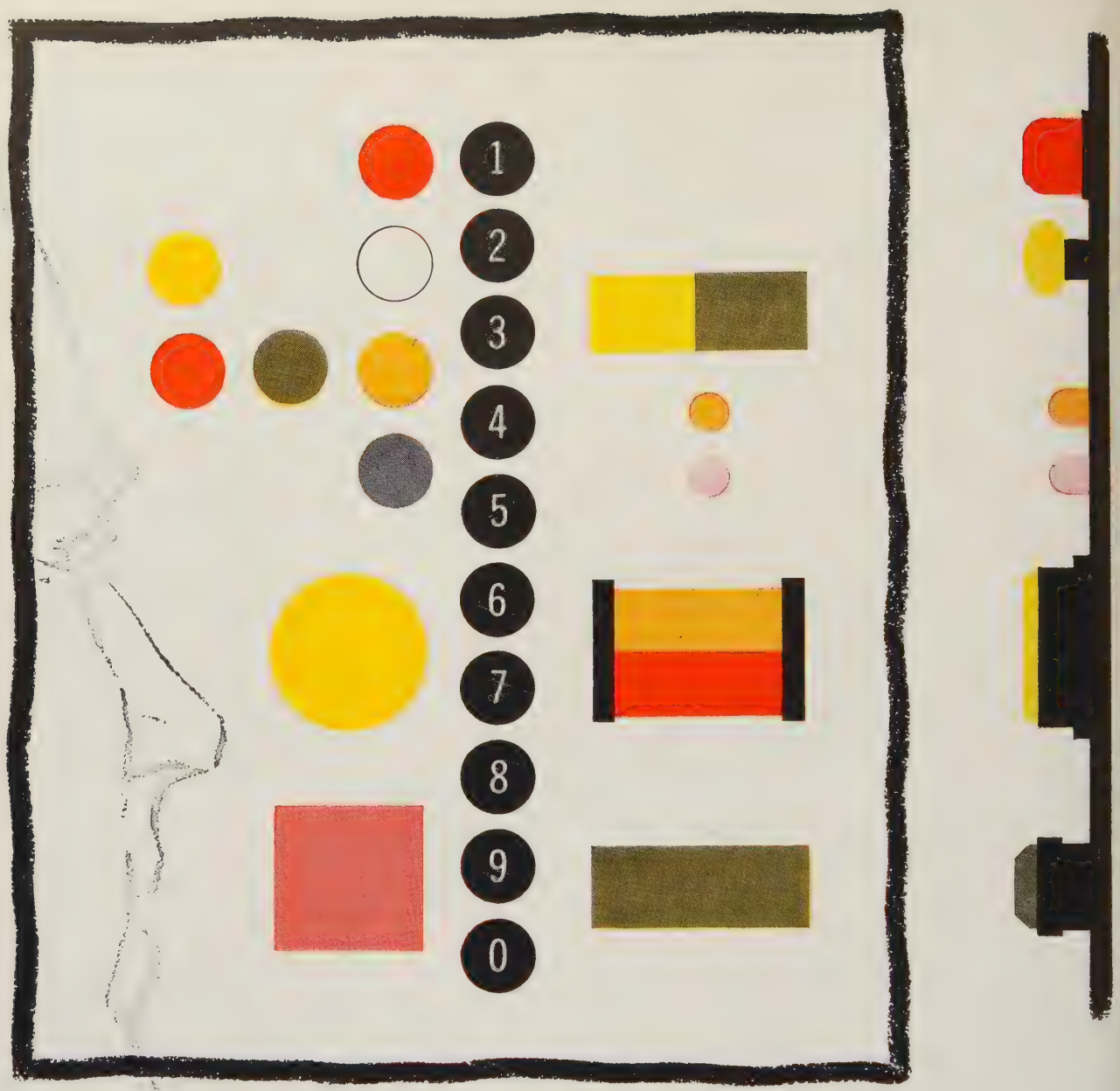
Westinghouse

Only large scale systems or very complex problems will require the full capacity of the Westinghouse WDP-400. One such mission might be a round trip to the Moon. The system computer could handle navigation, rendezvous in Earth and Moon orbits and propulsion programming.

Years of research and use-experience have brought increased reliability, cuts in weight and volume, and improved packaging. For example, both the WDP-167 and new WDP-400 have been developed to operate at 85° C.—where many others fail.



A molecularized computer, in which single semiconductor blocks perform multiple functions, is being developed at Air Arm for missiles or satellites. It is 1 10 the size of a conventional computer. Above, right, a tiny multi-purpose gate with resistors, diodes and transistors diffused on a silicon wafer, does the same job as the larger unit.



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ure may be raised slightly to 2800-900 deg F. Thorough degreasing must precede annealing.

Data on the oxidation resistance of 90Ta-10W are still limited. Work at Battelle Memorial Institute has fixed one point on the alloy curve with respect to the oxidation resistance of pure tantalum, giving the designer confidence in the improved characteristics of the 90Ta-10W. Battelle researchers measured the metal loss rate at 2190 deg F as 8.3 mils/hr for pure tantalum as against 7.5 mils/hr for 90Ta-10W. A simple aluminum and tin coating applied by spraying followed by a vacuum diffusion treatment developed by Sylvania's Sylor Division protects 90Ta-10W for over one hour at 3000 deg F under cyclic and creep loading conditions.

In suitably equipped shops, ingots can be forged into rod or sheet bar at 2000-2500 deg F. Protection during heating by coating cuts scrap losses, but is not a requirement for good forging. After 30 minutes' conditioning and annealing at 2900 deg F, the forged pieces are recrystallized and may be cold-rolled to sheet as thin as 0.01 in. without intermediate anneals. The sheet can be cross-rolled to increase the width.

Water vapor and oxygen must be excluded

The alloy can be welded with a permanent tungsten electrode in an argon atmosphere. The welds are more sensitive to contamination than those of pure tantalum, and water vapor and oxygen must be carefully excluded from the hot weld area. Electron-beam welding is also satisfactory.

The success of any given shaping operation using standard metalworking methods depends on the inherent properties of 90Ta-10W:

- Because of its high yield strength and higher modulus, the alloy requires greater powers than do materials of lower strength.
- The alloy has the same high ductility and low rate of workhardening as does pure tantalum. The spread between yield and tensile strengths, however, is not as great, and cold-forming therefore must be done very carefully. Sharp corners should be avoided.
- The alloy tends to gall and seize. Good lubricants—e.g., fatty-base or chlorinated oils—should be used. Soap or tallow is suggested for spinning operations. Ampco bronze or a similar material should be satisfactory for tooling.
- With present methods, sheet must always be formed cold to avoid interstitial pickup and embrittlement.

The machining methods are similar to those used for pure tantalum, with the harder 90Ta-10W actually showing improved characteristics because of a reduction in the tendency to gall and tear. High speed tool bits are used, and speeds and feeds similar to those for copper are recommended. There is no difference in machinability between the cold-worked and annealed states.

The recommended tool-point geometry for machining is: approach angle, 20 deg; side relief, seven degrees; side rake, 45 deg; back rake, 10 deg; end cutting angle, 10 deg; nose radius, about 0.015-0.02 in. The tool must be set on the center line and kept very sharp.

The best results have been achieved at 50 sfpm with a feed rate of 0.012 in. and a 0.06-0.07-in.-deep cut. Chip breakers are generally unsatisfactory, because of the ductility of the metal. Machining is usually done dry. When a lubricant is needed, trichlorethylene has proved best.

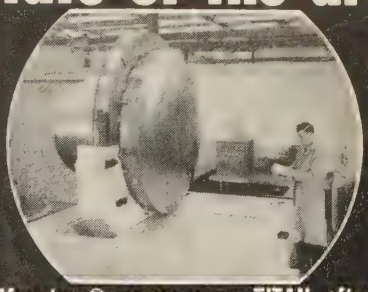
Standard drills can be used

Drilling can be done with standard high-speed drills backed off so that they will not score or dig the hole. Speeds should be low (30 sfpm) to moderate. The work should be flooded with lubricant. The same general procedures apply for milling. The cutters should be staggered-tooth types with plenty of back and side relief.

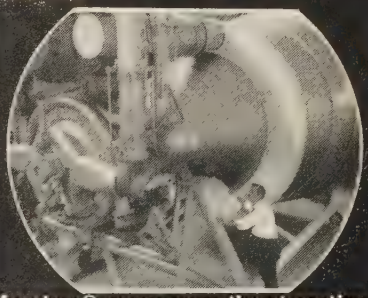
Threads can be cut, but thread rolling is cheaper. If the threads are machined, the tool should have plenty of top rake and should be fed so that it cuts on one side of the thread angle. Coarse threads are harder to machine than fine threads.

The new alloy is available in a number of forms. NRC, for instance, is supplying billets up to six inches in diameter and several hundred pounds in weight. Sheet widths of up to 12 in. are available in gages down to 0.01 in. Both thinner and wider sheets are expected in the near future. The first rod and wire orders are being processed, and methods for making tubing are under development.

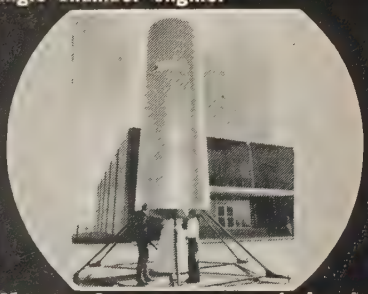
advances in the state of the art



Mecatorn® power spun TITAN after body with heat sink type nose cone attached.



Mecatorn® power spun throat section for Rocketdyne 1,500,000 lb. thrust single chamber engine.



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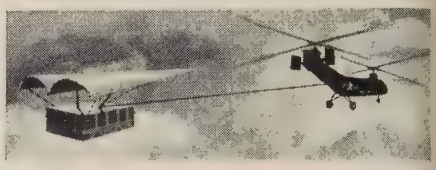

Ryan Flex Wing enables helicopters to tow several times the cargo or fuel they can carry

Ryan has received several contracts from NASA and the military services to explore and develop the more promising Flex Wing applications. Pioneering an entirely new concept, such as Flex Wing, is typical of Ryan's Space Age capabilities.

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SEPTEMBER 1961

aerospace electronics

SO SMALL that 20,000 can fit on a postage stamp, this experimental transistor, developed by RCA's Princeton Labs, is made by depositing thin films by evaporation on an insulating base. Three of the transistors have been made in special elongated form on a glass base for testing. Formed from films of cadmium sulfide and metal deposited successively, each is only a few ten-thousandths of an inch thick.

SKYBOLT ALBM WILL BE GUIDED BY CELESTIAL-INERTIAL SYSTEM

USAF's GAM-87A Skybolt ALBM, will be guided by a celestial-inertial system developed for Douglas by Nortronics. Component subcontractors to Nortronics on the system (which is largely a redesign of the Mark I "astro-inertial guidance" used on the now-obsolete Snark, and reportedly much more precise) include: General Electric, Kearfott, Motorola, Bell Aircraft, and Texas Instruments.

Major modules of the system are distributed between the missile and the ALBM's B-52H "flying launcher" to keep equipment in the bird down to a minimum. The missile will carry the celestial-inertial system, a digital computer, and supporting flight control electronics. A solid-state digital computer aboard the B-52H will figure the inputs to be inserted continuously into the bird up to the time of launch.

Floating nuclear powerplant

A floating nuclear powerplant is to be built by Martin under an Army contract amounting to just under $17 million. The Army plans to use this system—a 10-kilowatt plant installed in the hull of a modified surplus Liberty ship—to supply electric power to ports or coastal facilities. The scheme has obvious advantages in meeting power needs to replace facilities destroyed by enemy attack or supplementing existing power sources in a critical area. Another possibility that would be worth looking into is the use of this mobile nuclear power plant to power undersea detection networks of powerful active sonar installations. At present, undersea detection stations are fed power by marine cabling from shore terminals.

Latest aerospace electronics firm to take the plunge into undersea engineering is Loral Electronics. The firm decided to get deeper into the field by acquiring the services and patents, products, and inventions of Dr. Dmitri Rebikoff, a renowned French expert on underwater vehicle and instrument design. The transaction gives Loral rights to a series of one- and two-man operated and remote-controlled underwater vehicles that can serve for oceanographic exploration or reconnaissance down to considerable depths. Other items that Rebikoff brings to Loral include underwater lighting and photographic equipments, automatic pilot and drift meter devices, a horizontal periscope, and submarine control systems.

SYSTEM PROVIDES RADAR AND SYNTHETIC DISPLAY ON ONE PPI

Marconi is developing what they believe will be a "world first" in radar display units —a compact system that will provide on a single PPI scope both radar and synthetic display facilities. The British firm expects to be ready to deliver the unit in 1963.

The firm reports that the unit can be used as a display unit in its own right or integrated in existing console systems. Another feature is the use of comprehensive protection circuits.

To get character reading capability into the device, the big problem is to combine both small overall size and high speed movement of the spot beam. This requirement calls for high voltages or currents and therefore big CRTs. Marconi resolves this problem by providing for retention of the conventional low-current PPI time base, using special boost circuits that are brought into action automatically when the writing beam must move quickly from one point on the tube to another, and the use of a separate amplifier and coil assembly to initiate the very high speeds demanded in writing symbols.

Thin-film transistors made in lab

Thin-film transistors were produced experimentally at RCA Labs. The transistors are made by evaporating successive films of cadmium sulfide on glass plates to create a device only a few ten-thousandths of an inch thick.

In conventional transistors, electrons flow more or less freely through the semiconductor material between two of the contacts. The third element provides control by reducing the current flow in varying degrees.

The cadmium sulfide device has much better insulating properties than do germanium and silicon semiconductors, and there is therefore less current flow between two electrodes. The third element of the GaAs transistor provides control by increasing the electron flow in varying degrees.

RCA Labs' technique, according to vice president Dr. James Hillier, points to low-cost mass production of entire transistor circuits containing hundreds or thousands of active elements. A complete three-state thin-film amplifier circuit could be produced on a surface only twice as wide as a human hair, Hillier says.

Another important thin-film development had been announced earlier by Philco. Called a "new class of active components," Philco's "metal interface amplifiers" are made of a thin-film sandwich of metal, metal oxide, and metal placed on a germanium substrate.

Though the device is not a transistor, the two metal layers and the substrate serve as emitter, base and collector, respectively. The device has high conduction from emitter to base, produced by a quantum-mechanical tunneling process through the oxide insulator.

The electron current through the metal base uses *majority* carriers, while in transistors the base current uses *minority* carriers. Gating, switching, and mixing are foreseen by Philco as the eventual functions of the new device.

APOLLO STUDY INDICATES SHIELDING UNNECESSARY

Geophysicists at Martin completed a six-month feasibility study of Apollo for NASA and concluded that extensive shielding probably is unnecessary for manned spacecraft. This means that we could either put more useful electronic equipment on board or have lighter overall spacecraft with relatively more flexibility in the mission.

The experimenters found that the vehicle shell and equipment arrays in it were adequate protection against the normal expected radiation exposure fields: Van Allen Belts and sporadic solar flares.

Martin used an extensive spaceflight simulator to plot takeoff trajectories, automatic pilot characteristics, rendezvous in space with other vehicles, and re-entry. The study indicated that the success of the manned vehicle would be largely dependent on its sensors and navigation equipment, which must keep it on a trajectory that avoids the greater part of the Van Allen Belt.

ABCD concept simplifies data set-ups

A building-block design approach to digital communications is ACF Electronics' answer to the conglomeration of communications and data processing installations in large firms and the military. The "ABCD" (ACF Building-block Communications Devices) concept calls for interchangeable "plug-in" units that adapt all kinds of existing data equipment (teletypewriters, data transceivers, fax machines, and paper- and magnetic-tape machines) for transmission over standard telephone lines.

Until now, ACF says, the user has had to buy different adapters for each type of data equipment. With ABCD, he will be able to set up his own communications system with a minimum of equipment and be able to expand later on without duplication. The building blocks mark ACF's entry into the communications data processing field, which is attracting quite a few aerospace electronics companies.

Orders for their electrically suspended gyro have gone over the $8 million mark, reports C. L. Davis, vice president in charge of Minneapolis-Honeywell's Aeronautical Div. Operating time on the developmental type of gyro is piling up, too, he notes, one having already reached the 2000-hr point with no difficulties.

Latest contract awarded was from ASD to build advanced models of the airborne ESG for USAF evaluation. Aeronautical is also building an ESG that Navy wants to evaluate for possible use in the Polaris navigation system.

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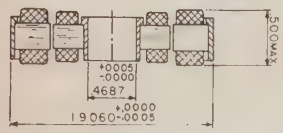

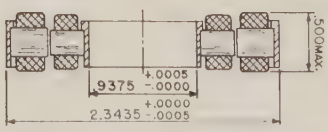

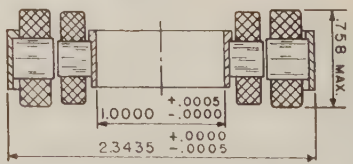

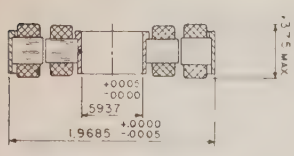

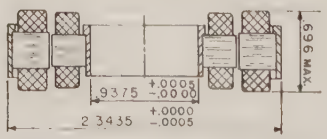

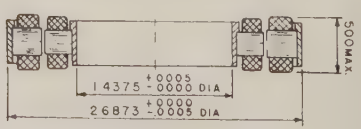

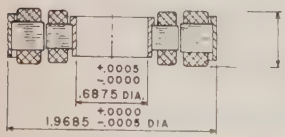

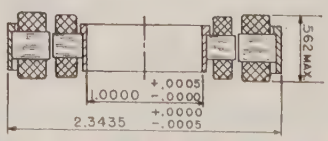

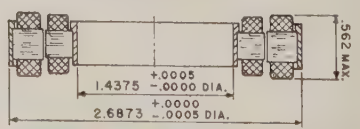

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CAPSULE WILL ORBIT 300 MILES OVER EARTH TO TEST 50-WATT FUEL CELL BATTERY

At GE's Missile & Space Vehicle Dept., work has begun on the development of an aerospace test capsule for testing a 50-W fuel cell battery. This capsule will be sent aloft into orbit at 300 miles over earth for a 30-day test during which it will convert the chemical energy of a hydrogen-oxygen fuel to electric power.

The battery is made up of 30 individual cells with a combined output of 6-28 V. Ion-exchange membrane cells will allow the required interchange of the two gases whose reaction will yield both electric power and water.

The final fuel-cell capsule system will include a hydrogen and oxygen supply, pressure regulating equipment, fuel cell modules, water removal apparatus and storage, heat dissipating structures, instrumentation, and telemetry.

Orbiting fuel cell will be operated intermittently for 30 days in zero-g condition at varying loads between no-load and full-load. The test capsule will have a volume of six cu ft and weigh about 100 lb. It will be similar to the power source that GE is developing for an Army-Marine battlefield surveillance radar.

The orbital test is expected to give answers to the poser of how fuel cells will operate in relatively long-term zero-g environments. Ordnance engineers say they expect to develop a 500-W, 28-V fuel cell for spacecraft in the foreseeable future, based largely on the findings of the present orbital test.

Cryogenic gyro's niobium sphere rotates in magnetic field

GE Ordnance has completed preliminary tests on its cryogenic gyro and is proceeding with development of the device for Marshall Space Flight Center. Karl F. Schoch, project engineer on this development, reveals that removing most of the air and other gases from around the rotating niobium sphere eliminates one of the major sources of friction—leaving the ball to spin freely in virtually nothing but a magnetic field.

He points out that error is also caused by any part of the sphere being "out of round" even slightly. For this reason, the niobium ball is superfinished to a roundness tolerance of 10-millionths of an inch.

The gyro ball's concentricity, says Schoch, can only be checked while the sphere is at near absolute-zero temperature (—459 deg F). Only at this low temperature, he explains, can the ball be suspended in a magnetic field.

Ordnance had to develop a special measuring device for checking concentricity. Since there is no metal-to-metal contact in this gyro rotor, other than conventional pickoff techniques (probably optical) have to be used.

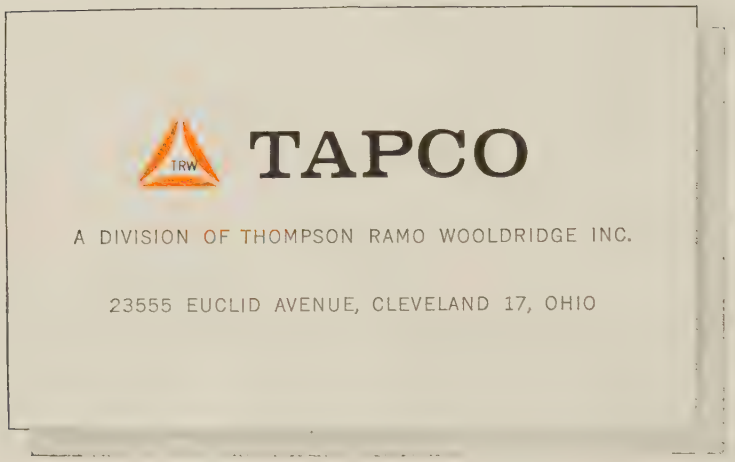
According to Schoch, forming work on the niobium ball is nearly complete and operational tests should begin this Fall.

Sylvania completed an R&D program for USAF that resulted in the development of a voltage-tuneable, backward-wave magnetron with a tuning range of 10.8-15.0 kmc. Lt. M. M. Heil, project engineer at AF Electronic Technology Lab, says the units will be used to extend the frequency coverage of present and future electronic systems. Conventional backward-wave maggies, he says, operate at frequencies of only up to 11 kmc. Sylvania's new maggies provide about 100 W cw power output over the increased frequency band.

ELECTRIC DEPTH GAGE HAS GREATER RELIABILITY AND ACCURACY

An electric depth gage of great accuracy has been developed at Westinghouse' Ordnance Dept. to take the place of the conventional mechanical device. According to J. H. Clotworthy, manager of Ordnance, the new gage achieves "three to five times the accuracy" of the conventional type and works reliably at depths as much as five times those reached earlier.

Exact depth measurements, he points out, are highly important to the commanders of nuclear subs, particularly in finding position by ocean floor contouring and in preparation for launching Polaris.



The calling card of subcontractor versatility TAPCO is a major facility offering research, design, development and production of systems, subsystems and components to the missile, aircraft, ordnance, marine, electronic and nucleonic industries. Proof of the quality and advanced nature of TAPCO capabilities lies within such prominent programs as SNAP, Sunflower, Pershing, Bomarc, Terrier, Tartar, Polaris, Minuteman, F-105, B-58, B-70, X-15, Mercury, Dyna-Soar. ADVANCED ENERGY CONVERSION SYSTEMS: Closed-cycle Rankine turboelectric (water, mercury, potassium, organic); turbine APU's; MHD; thermionic; fuel cell. Energy sources employed include solar, nuclear reactor, stored thermal energy, chemical and cryogenic fuels. ADVANCED PROPULSION: Arc ion rockets; plasma accelerators; ion propellant feed systems; reaction flight control systems; attitude control systems; vector nozzles; vernier rockets. ADVANCED ELECTRIC POWER GENERATION AND CONTROL: Brushless alternator and static circuit systems operating from any energy source and in ambients to 1000F. Analog/digital servo subsystems. Static standby power supplies for uninterrupted transfer of power. INTEGRATED ENVIRONMENTAL CONTROL: Space vehicle temperature control; space vehicle atmosphere control; closed-cycle oxygen regeneration. MISSILE LAUNCH AND SUPPORT: Mobile, air-portable transporter-erector-launcher vehicles; integrated launching and control systems; special airborne and ground test equipment. UNDERSEA SYSTEMS: Propulsion and control; submarine detection systems; drag reduction; hydrogen generation; special hydrodynamic studies. FLUID SYSTEMS: Aircraft engine-driven, booster and after-burner fuel pumps; flow control and relief valves; linear and rotary hydraulic actuators. Cryogenic fluid systems; hot-gas servo systems. SPECIAL INSTRUMENT PRODUCTS: Weather and gas line instrumentation; precision magnetic storage devices; signal-conditioning subsystems. FM VIDEO TELEMETRY SYSTEMS: Broad-band transmitters and receivers; multiplexing; subcarrier channels; automatic servo-controlled tracking. MATERIALS TECHNOLOGY: Develop extrusion, forging, welding and coating processes for superalloys and refractory metals. Study liquid-metal corrosion. Perform applied research and application engineering for plastics, ceramics, high-strength metals and refractory metals for hot-gas servos, rocket-engine components, high-temperature motors and unusual power-generating equipment.

No. 32 on Reader Service Card

Another application for an electric depth gage might be in getting precise measurements of the contents of fuel tanks in storage installations. According to Clotworthy, gage information is easily displayed on a numerical meter similar to an odometer.

The new design, he explains, determines depth from water pressure, but by a different method from the conventional device. Bonded to the side of a cylindrical metal tube is a wire. When water pressure inside the tube goes up, the tube expands and thus stretches the wire. By attaching a tachometer to the servomotor powering the meter display, rate of depth change is also determined.

Disclose criteria for missile telemetry link

Design criteria for a basic UHF telemetry transmission link to meet missile program requirements of the next decade were made public in an NOL report. It gives detailed recommendations on capabilities and design for the transmitter, receiver, preamp-converter, distribution amplifier, main receiver, and receiving antenna portions of the telemetry link. Emphasis is on flexibility of operation and adaptability of the ground station complex to UHF bands not now assigned. (See *S/A R&D Technical Handbook 1961-62, "Test Engineering: State of the Art."* You can order the complete report, entitled "Design Objectives for Telemetry R-F Transmission Links for the Period 1960-1970," by T. B. Jackson, NOL, by sending 75 cents for document PB 171 690 to OTS, U. S. Dept. of Commerce, Wash. 25, D.C.

Raytheon is working on the electronics portion of an advanced guidance system designed by MIT's Instrumentation Lab for Polaris missiles.

SYLVANIA STUDYING SELF-ADAPTING COMMUNICATIONS

Self-adapting communications are being studied by Sylvania's Applied Research Lab under an RADC contract worth $81,000. Object of the study is to evaluate methods of improving communications by adapting the transmitter and receiver to changes that occur in the transmission channel: signal fading, varying noise level, etc.

Dr. Philip Bello, project engineer on the study, says that receivers can be designed with automatically adapting circuits to maintain reliable signals in the face of such disturbances. Also, he feels that transmitters can be made adaptive by providing information feedback from the receiver. The data would be used to control the transmitter's signaling system to get a stable signal.

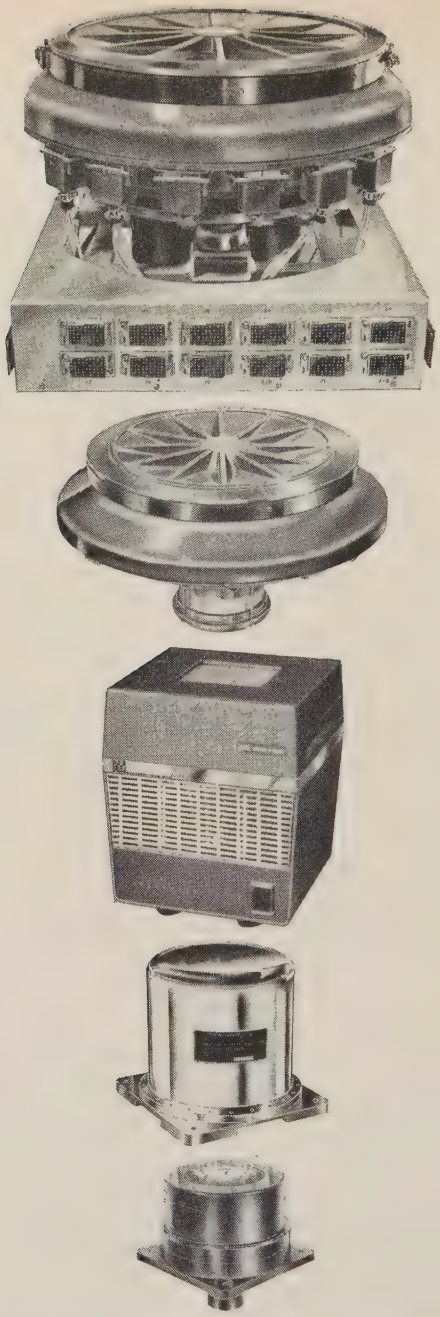
The self-adapting comm study, explains Dr. Bello, is partly an outgrowth of several programs at the Lab involving applications of statistical communications theory to both theoretical and experimental studies of advanced communication system concepts. These include work in secure communications, application of feedback principles in on-off noisy, fading systems; and application of advanced digital signaling techniques (including aspects of feedback communications) to interference-free satellite relay communications.

SOLAR CELL SIMPLIFIES SATELLITE POWER SUPPLY PROBLEMS

A more powerful blue solar cell has been produced by Hoffman Electronics with the aid of a unique, more accurate solar simulator. It gets its name from the fact that it has greater response in the blue region of the radiation spectrum, making it more useful in the space environment.

The new cell will simplify the problems of the satellite power supply engineer, says Dr. Bernd Ross, of Hoffman. With it the designer can now count on about 9.5-10 W per square foot of solar cell panel surface area. Before, you could only get about 8.5 W. He adds, "This efficiency will be even more important as space vehicles go out to Mars or other regions far from the sun."

The blue solar cell is the result of the development by Hoffman of a solar simulator that reproduces the solar radiation, heavy in blue energy, of outer space.



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Battle for favored positions in the nation's commercial communications satellite program has produced a ludicrous situation wherein the Senate Small Business subcommittee on monopoly has indirectly espoused the cause of industrial giants like General Electric and General Telephone & Electronics. The subcommittee is checking into the possibility that AT&T will dominate the ownership and operation of the future satellite system, thus tightening its grip on the virtual monopoly it now enjoys in domestic and U.S.-to-overseas telephone communications.

Many in Congress feel that the Federal Communications Commission has given AT&T a carte-blanche invitation to take over. The commission, acting on the heels of President Kennedy's decision to make the commercial communications satellite system a venture of private enterprise that should be put into operation as soon as possible, named the ten U.S. companies engaged in international common-carrier communications as eligible for ownership and operation. The FCC dictum excluded such interested parties as GE, GT&E, Lockheed, and Hughes Aircraft. It included only four companies with the technical competence to make major contributions to the design and development of the system—AT&T, ITT (eligible because of its ownership of American Cable Co.), RCA Communications, and Western Union. The last-named company evidently will also become ineligible for satellite ownership-operation if the pending sale of its overseas telegraph holdings to American Securities Corp. goes through; the terms of the sale are now up before the FCC for approval. Western Union agreed in 1943 to divest itself of its overseas cable system as part of the plan under which the FCC allowed a merger with Postal Telegraph.

With this lineup, it's hard to imagine the team turning into anything but a three-company show with AT&T playing the starring role.

The Justice Dept. is considering ordering AT&T to divest itself of its overseas operation. If this happens, it will also render AT&T ineligible for the satellite team, at least under the present rules. Even if so ordered however, the divestiture—like Western Union's—could take eight to 10 years or more before a sale agreement could be reached and approved by the government. By then the ground rules might be entirely different.

The nation faces a dichotomy: it wants the commercial communications satellite to be a private venture and it wants operation as soon as possible—yet it does not want to build a monopoly that might do irreparable harm to the private enterprise system.

One way out of the situation, suggested by FCC and some members of Congress, is to attach very tight government controls to the space communications system. This could result in a cumbersome, "name-only" private enterprise.

There's no doubt that only a handful of companies have the know-how and money to put up a commercial satellite system. All of these companies are very large, and no matter who does the job, all of them will gain tremendously from the billions of dollars in space technology R&D that the government has spent.

Undoubtedly AT&T could put up its simple, 10-year average reliability system within the next few years, as it claims, and would do it alone, if permitted. So far it has been the only company willing to risk so much of its own capital on the project. Most of the other companies that have advanced proposals hope to finance their system either through direct government support or through pooling of resources with other companies.

A company spokesman told SPACE/AERONAUTICS that the difference between the AT&T proposal and those advanced by aerospace companies was that AT&T wanted to put up an operating system in the shortest possible time, while the aerospace companies' prime interest was in using their proposals to obtain government study and development contracts. To point this up, the spokesman said that AT&T's proposal was based on existing, proven hardware whereas the others needed boosters not yet developed, and stabilization and control systems of questionable reliability.

The big difference between AT&T's proposal and the others that have been advanced is that the former is willing to buy reliability and time for overall system inefficiency, whereas the others are aiming for higher efficiency but are willing to spend time and introduce potential unreliabilities to gain it.

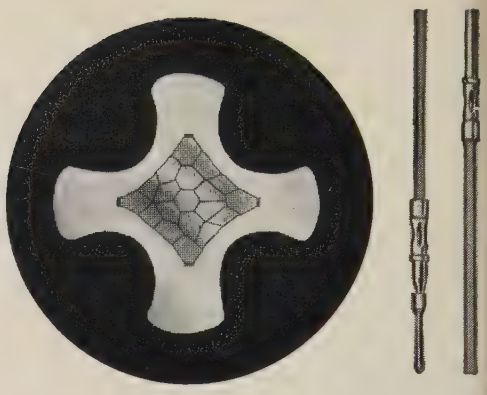
AT&T's system was designed primarily for the lucrative U.S.-European communications traffic. The company apparently feels that countries should develop communications needs before they are serviced by satellites rather than that satellites will encourage communications between relatively underdeveloped countries and the more advanced parts of the globe.

Lockheed, which spent some $200,000 on a study of satellite communications, appears to have given up the idea of actual participation in the commercial system. It feels that the decision of the FCC allowing this privilege only to international common carriers is sound. Lockheed hopes to supply boosters and tracking and missile systems to the eventual operators.

Hughes Aircraft, which was also shut out of participation, is currently negotiating a four million dollar contract with NASA to build three 50-lb satellites to be launched into 22,300 mi, 33-deg inclined orbits for study of satellite operation in 24-hr synchronous orbit. The project will be known as Syncom. Its satellites will remain roughly over the same longitude off the east coast of the U.S. and will appear to follow an elongated, figure-eight pattern between 33 deg N and S latitudes.

General Telephone & Electronics, through its president, Dr. Herbert Trotter, has called the FCC action of limiting participation to the "so called" international carriers "absurd". He points out that such companies on the allowed list as Hawaiian Telephone, Press Wireless, South Puerto Rico Sugar Co., Tropical Radio Telephone Corp. and United States-Liberia Radio Corp. have never shown interest in contributing technology or funds to a satellite communications system.

PATTERN FOR PERFORMANCE



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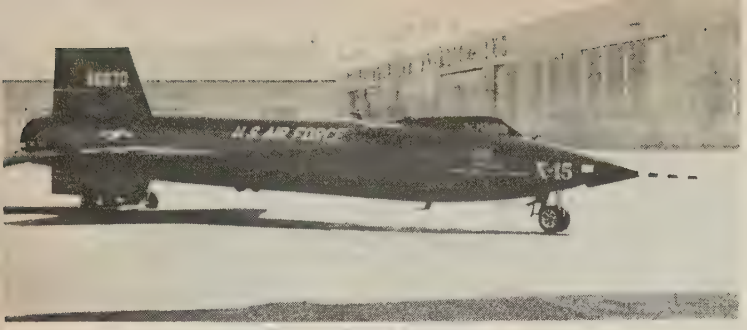

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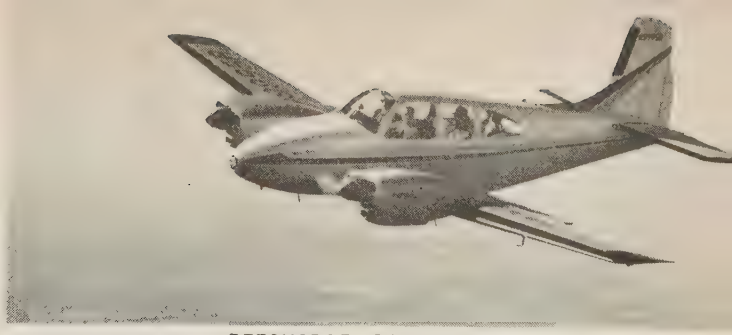

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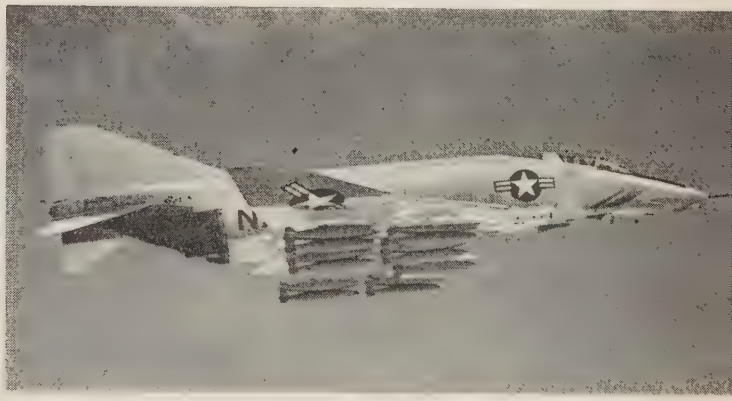

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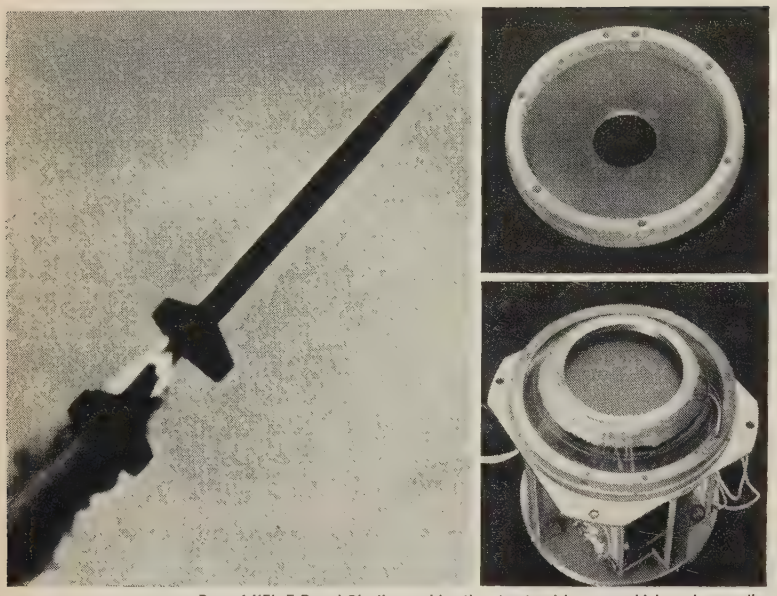

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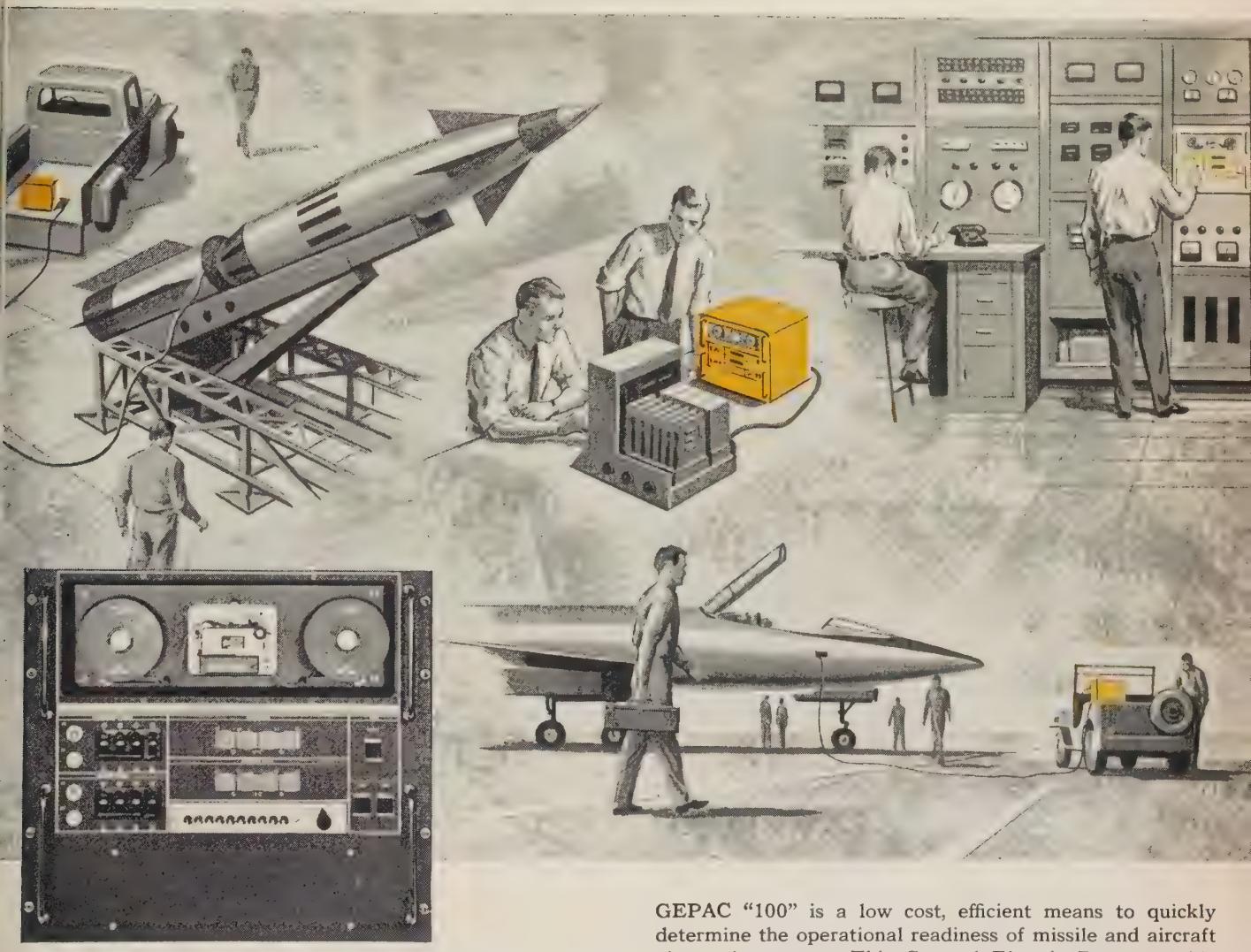

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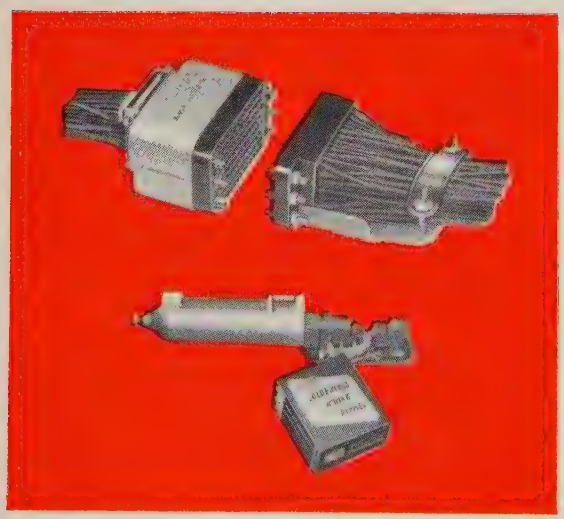

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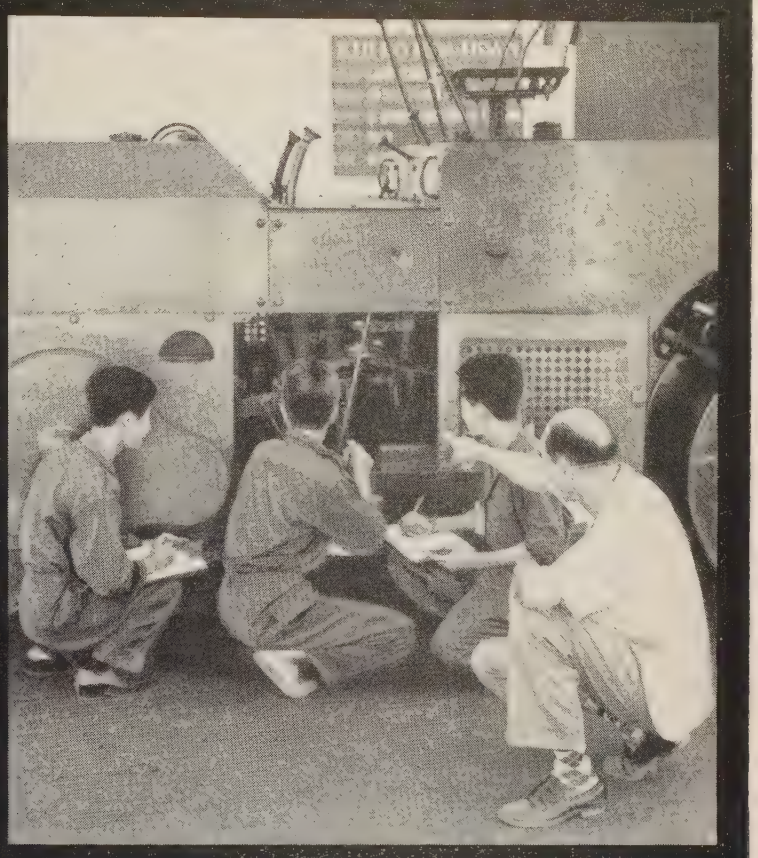

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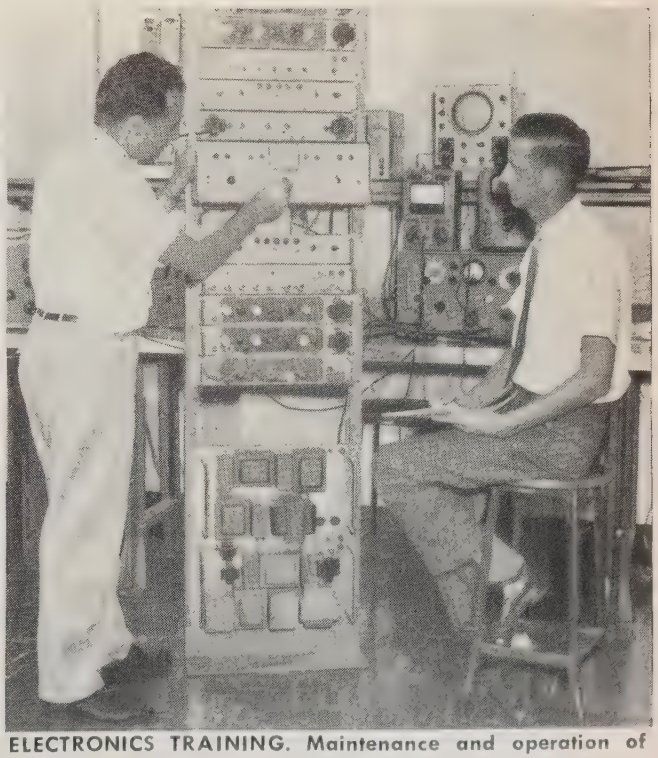

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by **James Holahan,** Electronics Editor

Survey

Communications satellites:
the technical problems

THE PROSPECT of operational communications satellites has raised such a plethora of political, economic, legal, and social questions that the many, extremely difficult technical problems that also must be solved have almost been overshadowed. These technical problems belong in the realm of engineering—communications satellites are feasible without further breakthroughs (which doesn't mean that the successful development of more powerful boosters, nuclear power supplies, solid-state microwave amplifiers and reliable attitude control systems would not make the satellites easier to design and operate).

Three development programs are underway on active communications satellites:

- Advent, a tri-service project run by the Army;
- Relay, a NASA project;
- TSX (for "telephone satellite experimental"), a private venture by American Telephone & Telegraph.

Advent is expected to lead to an operational military system, and the final satellites launched in the course of this program may be the actual operational space relays. The first operating satellite communications system, however, will probably be owned and operated by private U. S. companies (with the participation of foreign companies). President John F. Kennedy recently gave private enterprise the green light for such a venture, and the Federal Communications Commission has already named 10 U. S. international communications carriers as eligible to own and operate the system.[1]

The commercial system is to be put up as soon as

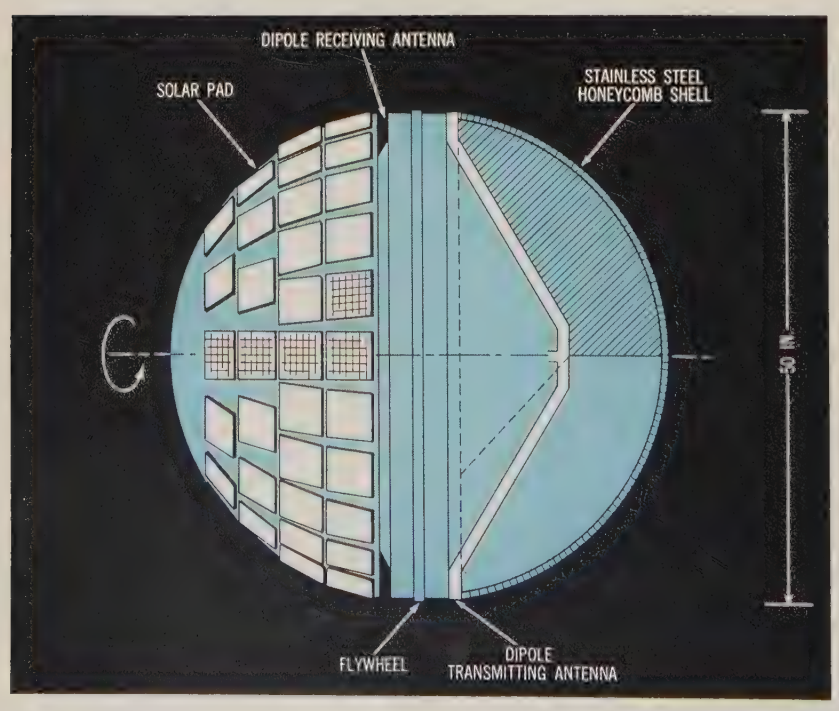


FIGURE 1: Active satellite of the type AT&T will use in its TSX experiment. Its total weight, restricted by booster limitations, will be about 150 lb. The original approximate design weights were: communications package, 185 lb; shell and flywheel, 28 lb; ribs, 3 lb; solar cells, 7 lb; 0.070-in.-thick cover glass for cells, 27 lb; pads for solar cells, 21 lb. A total of 76 solar cells will be used (76 on each of 152 pads).

IN BRIEF

While they don't require any breakthroughs to become operational, communications satellites still face a number of serious engineering difficulties. The chief problems are how to achieve ultrareliability in a virtually unknown environment and how to get higher sensitivity and effective radiated powers in the payload without excessive reliability and weight penalties. In addition, problems arise in areas like thermal control, attitude stabilization, position-keeping, booster performance, trajectory, and antenna directivity.

Random low-altitude, 24-hour earth-synchronous, and low-altitude equatorial orbits all have been proposed for communications satellites. Each type of orbit offers certain advantages and makes certain trade-offs. In view of the President's call for a communications satellite that can be put up "as soon as possible," the random low-altitude orbit looks like the best bet, since it involves the least extension of the state of the art. This orbit requires a highly complex ground station and a large number of satellites to make up for extremely simple satellite-borne equipment.

possible, and Relay and TSX both probably will serve as testbeds for it. The commercial system is intended to provide—via earth-orbiting relays—worldwide wideband communications for several hundred telephone channels (or the equivalent in channels for telegraph, facsimile and machine-processed data) and a single television channel.

To be economically feasible, the satellite elements of the system will have to operate at least 2-5 years without failure. For the military satellite, performance will be more important than economic considerations. Message security and anti-jam requirements will probably make it heavier and more complex than the commercial satellite.

Environmental conditions and reliability pose the worst problems for communications satellites. Relatively little is known about the space environment, especially at the high attitudes at which communications satellites will operate. The greatest environmental hazard appears to be harmful radiation, which will be a factor no matter where the satellites orbit.

The satellite elements most sensitive to such radiation are solar cells, transistors, and exterior insulations.

(1) These 10 carriers are American Cable & Radio, AT&T, Hawaiian Telephone, Press Wireless, Radio Corp. of Puerto Rico, RCA Communications, South Puerto Rico Sugar, Tropical Radio Telegraph, U. S. Liberia Radio, and Western Union Telegraph. (However, Western Union is divesting itself of its international routes, acting under FCC orders, and therefore probably will actually not be eligible for the satellite project.)

ON ADVENT satellite, the solar cells will be turned so that they always face the sun. Attitude control and position-keeping will also be provided.

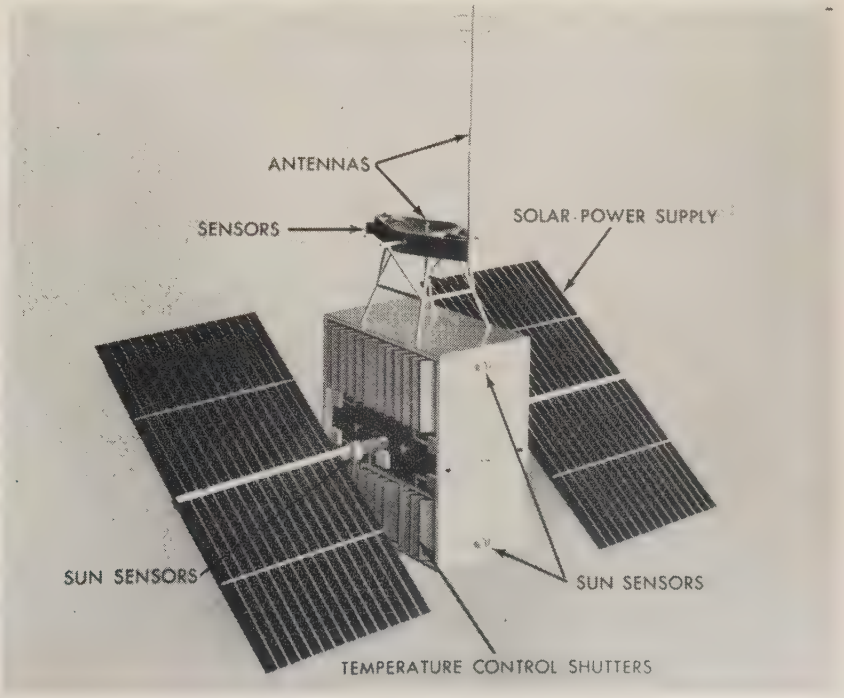


Table I:
U. S. Boosters for Communications Satellites

	Availability	Payload Capacity (lb)		
		24-Hour Orbit	Low Orbit	Cost per Firing[1]
Thor-Delta	in use	not feasible	100-200	$3,500,000
Thor-Agena-B	in use	not feasible[2]	200-400	$4,500,000
Atlas-Agena-B	late '61[3]	100-200	1000[4]	$7,000,000
Centaur	late '62[3]	1000[4]	not needed	$10,000,000

(1) For 10 firings per year. (2) Because of lacking "dog leg" capability, an equatorial orbit could be achieved (if at all) only with a substantially reduced payload. (3) First availability for government use. Availability for the communications industry may be delayed up to 18 months. (4) Possibly conservative estimates.

Solar cells can be protected by glass or sapphire coatings and transistors by lead shielding. How thick the coatings and shieldings must be depends on the nature of the radiation, which still has to be determined in experimental launchings. Solar cells also will be subject to micrometeorite erosion.

Thermal cycling is another poser. The temperatures on a satellite can change hundreds of degrees in a few minutes as the vehicle moves in and out of the sunlight. To cope with such changes, great care will have to be devoted to materials selection and thermal design. Another unknown is the "hard vacuum" of space. It could cause gases and liquid to leak, but it could also be used to advantage by the designer.

The reliability problem of a communications satellite basically is a matter of long life. The first satellite to be launched in the Advent program, for example, will be designed to keep at least two of its four wide-band communications channels in operation for a year. To meet this goal, its subsystems are being designed for a

U. S. Communications Satellites

Advent

The goal of this coordinated tri-service R&D effort under the direction of the Army Advent Management Agency, Ft. Monmouth, N. J., is to determine the feasibility of a highly reliable military communications system using multi-channel microwave relay satellites in a 24-hour, earth-synchronous orbit. Bendix Systems will design all spaceborne and ground communications equipment under contract to the Army's Signal R&D Labs. GE MSVD is responsible for the design of the satellite and the integration of all its systems, and Sylvania for the overall design of the two ground stations (at Ft. Monmouth, N. J., and Camp Roberts, Calif.) and of a shipboard station. Other principal contractors are Aerospace, Arinc Research, Booz Allen & Hamilton Research, Convair, Lockheed, Philco, and Space Technology Labs.

The design characteristics of Advent are classified. The Army has revealed, however, that the system will be designed for maximum message security and to block accidental and deliberate interference.

It is also known that Advent will have "multiple" voice channels. The first units are being designed for a minimum operating life of one year without failure.

Attitude and position-keeping control will be used, with IR cells as sensors and gas jets as activators. Temperature will be controlled by louvers.

Surprisingly, no TWT will be used in the system—Bendix reportedly will rely on a grid-type tube or a solid-state output device. This might indicate the use of relatively low (L-band) microwave frequencies for the space-ground link.

So far about $200 million has been allocated to Advent. Although it is a feasibility program, Advent may very well end up as a system of orbiting operational military satellites.

Relay

For this NASA communications satellite project, RCA will develop and build two barrel-shaped 100-lb payloads to be sent into a 45-deg inclined elliptical orbit with its apogee at 3000 miles and its perigee at 900 miles. The launcher will be a Thor-Delta. The first launch relay is scheduled for the spring or summer of next year, the second for winter '62-'63, from Cape Canaveral, Fla.

AT&T's station at Rumford, Me., and ITT's Nutley, N. J., facility will be used as ground terminals. Each payload will carry two repeaters for relaying telephone, telegraph, and TV. Commands from the ground stations will be used to select repeater and transmission modes.

Relay's up-link will be on 1725 mc; down-link, on 4170 mc; bandwidth will be 4.5 mc. The satellite transmitter will use a 10-W TWT. No attitude or position-keeping control will be included.

A follow-up Relay II project is in preparation for invitations to bid. Relay II will be launched from Cape Canaveral into an approximately circular "sub-synchronous" orbit at 5600 miles altitude. It will use attiude stabilization and possibly position-keeping to repeat its path over the ground once about every six hours. (In other words, it will spiral around the earth, with the same spiral recurring every six hours.)

The purpose of Relay II, it is believed, is to study the problems of the synchronous orbit without actually sending a satellite into a 22,300-mile equatorial orbit.

TSX

AT&T's experimental communications satellite program calls for two launchings, one in the spring or summer and the second in the fall or winter of next year, into a 45-deg inclined orbit with a 3000-mile apogee and a 600-mile perigee. Handled by NASA from Cape Canaveral, this should be the first satellite launching directed and financed by private enterprise.

Two satellites—with diameters of 34 in. and weighing about 150 lb each—are being built by Bell Labs for AT&T's experiments. The first satellite will be spin-stabilized and contain essentially isotropic antennas (dipoles) girdling the circumference of the payload; the second may use attitude control to permit the use of directive antenna and its 5-10 db higher effective radiated power. Each will use 6390 mc for the up-link and 4170 mc for the down-link.

The satellite-borne equipment will be simple. The active components of the repeaters will be solid-state designs, except a three-watt TWT, which will be the final RF amplifier of the transmitter.

The ground terminals will be at Rumford, Me., and Holmdel, N. J. The Rumford station probably will also be used as part of the eventual operational commercial satellite system. It will have a special 177-ft long horn-reflector antenna with negligible side and back lobes. Mounted on a two-dimensional track, this antenna will

minimum operating life of 20,000 hours. Bell Telephone Labs is designing the systems for its TSX satellites for a minimum life of five years and an average life of 10 years.

Achieving this unprecedented reliability will be a matter of applying, rigidly and intelligently, the vast knowledge we have already accumulated. Careful selection of materials and components on the basis of well-documented test data, simple configuration, component derating, redundancy, minimal use of moving mechanical devices, careful thermal design, clean-room assembly, multiple inspections, and the standard routine of "test, determine the failure cause, redesign, and retest" will have to do the job.

One of the bad problems in designing long-life equipment is how to figure out whether a device will last x years when you have only $0.01x$ years in which to test it? Accelerated life testing is being used widely, but no one is so far sure of its validity.

Both AT&T and International Telephone & Telegraph point to their success with repeaters in submarine cables. The voice telephone cable that AT&T laid under the Atlantic in 1956 is still working today, and there has been not a single failure in any of its 1500 tubes nor in any of its passive components. However, while there is a definite design correlation between submarine and space repeaters, it's also true that the latter must live in much rougher environment.

Several pieces of satellite equipment are especially critical for long life:

- *solar cells,* whose soldered interconnections may cause efficiency and reliability problems;
- *traveling-wave tubes,* which are likely to be used in most systems as power output devices and will have to be low-powered, since high power means high cathode current densities, which in turn mean short life;
- *insulation* on antennas exposed to radiation;
- *moving mechanical parts* like flywheels, gyros, and valving on reaction gas jets;
- *semiconductors,* for which radiation protection,

see only a 300-deg-K noise temperature when beamed skyward. The ground station will also contain a small digital computer to convert hte orbit numbers provided by NASA trackers into switching commands.

The TSX satellites will be launched by Thor-Delta boosters. AT&T's contract with NASA specifies that AT&T will pay for each launch whether it is successful or not. The cost per launch is believed to be six million dollars.

GE Proposal

This system of 10 equally spaced communications satellites in an equatorial orbit at 8000 miles altitude would have most of the advantages of the synchronous orbit but would avoid the danger of echo delay. A 160-lb system consisting of IR sensors, a flywheel, and nitrogen gas jets would be used for attitude control. Position-keeping would be controlled by a ground track and radio command system. (The satellite part of this system would weigh 1002 lb).

The operating frequencies would be in the 4000-6000-mc range, with 335.2 mc bandwidth required for the up-link and 500 mc for the down-link. Wide-deviation FM modulation would be used.

Each satellite would weigh 1002 lb and contain seven communications packages. Four of these would handle up to 300 voice channels each, one would handle TV (using a six-megacycle baseband), and two would handle small blocks of traffic.

General Telephone & Electronics Proposal

This system in a 24-hour earth-synchronous orbit would have 2000 one-way speech channels spaced at four kilocycles to give a total basebandwidth of eight megacycles. All ground transmitters would operate in a common RF band, using SSB-AM with suppressed carrier. One channel would be used for control and to provide a reference frequency for all stations. System switching would be under the control of a central digital computer.

The ground stations would use a large, fixed hemispherical antenna for transmitting and receiving. The antenna feed would be adjustable within about ±10 deg in azimuth to compensate for the daily motion of the satellite and for long-term drifts. The satellite repeater would use a 25-deg-beamwidth antenna. FM modulation, and a two-watt RF final in the transmitter.

Hughes Aircraft Proposal

This system calls for 28-in.-diameter cylindrical satellites weighing 33 lb each and launched into a 24-hour earth-synchronous equatorial orbit from the Pacific island of Jarvis, near the equator. The booster would be a Scout, topped off with two additional solid-propellant rockets.

Frequencies in the UHF region would be used for the up-link and about 2000 mc for the down-link. SSB-AM would be used from the ground to the satellite and wide-deviation phase modulation from the satellite to the ground. The satellite would carry a balanced linear IF phase modulator for making the modulation conversion.

AM, Hughes points out, provides multiple access to the satellite—any number of ground stations could share the available bandwidth on a frequency-division basis, and the satellite therefore could handle a large number of traffic routes. Because of hybrid modulation, a single channel could be time-shared for both directions of a voice message. There would be enough bandwidth for 300 voice telephone channels.

Eighteen watts of electric power would be supplied by solar cells and nickel-cadmium batteries. A cooled parameteric amplifier would be used in the ground station receiver.

The satellite repeater would use solid-state design throughout and would have a power output of one watt. It would repeat guidance as well as communications signals. The repeater receiver likewise would double as a command receiver and the repeater transmitter as a telemetry transmitter.

The payload would use both attitude stabilization and position-keeping, with nitrogen gas jets supplying the reaction energy.

RCA Proposal

This system would use two or three satellites in a 24-hour, earth-synchronous orbit. The frequencies would be above 800 mc. For the ground-to-satellite link, SSB-AM with pilot carrier would be used; for the satellite-to-ground link, a frequency-division multiplex-FM scheme.

There would be enough bandwidth for relaying at least "several hundred" voice-phone channels. The satellite output power would be a few watts and the antenna gain 17.5 db. Attitude and position control would be used.

Echo Delay

That evidently immutable law of nature that says that electromagnetic waves can not exceed the speed of light is at the root of a problem that threatens to disqualify the 24-hour satellite from service as a relay of telephone conversations. Because of this limiting velocity and the long path length from earth to the 22,300-mile-high satellite and back to earth, in addition to land-line travel, it would take about 0.6 seconds for the person at one end of a telephone line to hear what the person at the other end has just said. A similar appreciable delay could occur with lower-altitude satellites, too, if the message travels from origin to destination in several hops.

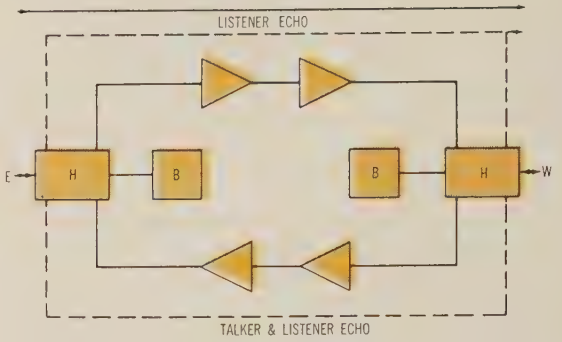
This delay may prove annoying, but it is not the real problem. The transmission line echo, a secondary effect, is the dangerous poser. This echo is present in all two-way telephone conversation circuits, but it becomes bothersome (and can even make a telephone conversation almost impossible to conduct) only when the delay is long.

The basic reason for the delay is that our telephone system uses a circuit of two wires rather than of four. Undoubtedly, if the telephone people could start all over again, they would install four-wire circuits. But it's too late to change.

Because the four-wire circuit used for long-distance transmission must couple into the two-wire circuit near the user's telephone, a hybrid amplifier has to be used where the circuits meet (see Diagram). This hybrid interconnects a number of circuits and therefore doesn't represent a perfect impedance match. The result of the impedance mismatch is the reflections, or echos, shown in the Diagram.

The telephone companies have long been aware of this problem. They have coped with it on long lines by using an echo suppressor that interrupts one transmission line while the party at one end is talking. But when delays are very long, tests show, often both parties tend to talk at once. This can cause a "lock-out," with neither party able to make itself heard. Present echo suppressors apparently add to the problem instead of reducing it.

Many companies—among them Bell Labs, General Telephone & Electronics, and ITT—are trying hard to find a better solution. Probably the most promising idea so



far has come from two General Telephone engineers who have designed what they call a "two-mode suppressor." In one mode, there is complete echo suppression while one party is talking without interruption from the other party—an open switch breaks the circuit in the unused direction of transmission, eliminating any echo path to the talker.

The other mode comes in—automatically and without notice to the talkers—to insert attenuation in the transmission path when one party is talking and the other interrupts. The switch is now closed, permitting simultaneous transmission in both directions, but with the attenuation in the lines providing partial suppression.

In view of the formidable nature of the echo problem, the question arises why the military should have chosen the 24-hour, synchronous orbit for its satellite communications (as it appears to have done). In answer, the Army Advent Management Agency only states that the military requirements are different from commercial ones.

What might lie behind that answer is that military two-way communications almost never involve what is normally meant by "conversation"—they are better described as message and reply transmission (the kind of transmission that takes place when a pilot talks to a control tower). Established procedures for this type of transmission make sure that the speaker transmits his full message before the person at the other end tries to reply.

temperature cycling, and sealing in a hard vacuum will all be problems;

- *batteries*, which should not have excessive charging rates if they are to have long life (a requirement usually met by carrying four to five times as many batteries as are actually needed) and must be well sealed to prevent electrolyte evaporation (believed to have caused a number of failures in satellite electronics).

Reduced to its essentials, a communications satellite can be considered a very-long-range microwave link. Instead of a hundred or so relay stations, however, only one is used. And this single station is entirely out of reach of maintenance, has to derive its energy from its environment, and is limited in reception sensitivity and RF output power.

For the designer, the difficult part of the communications satellite system is the satellite-borne equipment. Both the high cost of putting a payload into orbit (currently estimated at $10,000-100,000 per pound) and the limited power of our boosters restrict the physical size of the satellite payload (*Table I*).

As power supplies account for most of the payload weight, power drain must be held to a minimum. This limits the satellite transmitter's power output to a few watts, as does the fact that long-life, high-power amplifiers are just not available in the 1-8-kmc range (the most probable frequency band for the first systems).

The effective radiated power from the satellite could be improved by 5-20 some db by a directive antenna—at the price of going to attitude control, which would require over 100 lb of equipment in the satellite. Some of this weight loss, however, would be recouped by savings in the payload's power supply and transmitter through the more efficient use of the available power.

A more conclusive argument against attitude control can be made on the grounds of long life. Satellites with three-axis attitude stabilization have been launched, but none of them had a life of more than a few days. All attitude controls proposed to date rely either on

ioving mechanical parts (gyros or torque wheels) or n gas jets as secondary propulsion. The reliability of iese devices is questionable, and in the case of the gas ts their life would limit that of the whole system.

For communications, the satellite will contain a roup of repeaters. These will be receiver-transmitters iat will receive on one frequency and transmit on anther to avoid interference. Because of the long-life equirement, their design will have to be kept simple. 'or instance, many of the design proposals for comiunications satellites include receivers of low sensitivity. 'he ground station, on the other hand, would use a elatively high-powered transmitter (of 1-2 kw on the verage) feeding a high gain antenna.

One of the pitfalls of this arrangement lies in the anger of interference with existing land microwave nks; with which the satellite communications system vill share frequencies. How serious this danger is reiains to be determined. Along with the need for very-ow-noise reception, however, it will undoubtedly comlicate the design of the ground antenna by calling for ie ultimate in the suppression of side and back lobes. nccreasing the sensitivity of the satellite receiver vould of course reduce the ground-transmitter's power equirement, but only at the price of increased satellite veight and complexity.

The overall design of the communications system is iextricably tied to the type of orbit, which in turn epends on the available boosters and the vehicle guidnce, attitude stabilization, and orbit control (or posiion-keeping) systems. Three further generalizations an be made:

- As we have already seen, designers will tend to uild the complex elements of the system into the round stations to keep the satellite equipment as simple s possible.
- New boosters, power supplies, controls, and elecronics (which will undoubtedly be developed) will equire such extensive prove-out periods before they an be used in long-life systems that, for the foreseeable future, all communications satellites definitely will have to be ultra-conservative in design.
- Especially for commercial satellites, cost will play a large role in the choice of orbit and payload weight and the many system parameters governed by these two factors. (Multiple-payload launchings from a single booster, incidentally, would drastically cut costs.)

Three basic types of orbit have been proposed for communications satellites, all of them circular to insure uniform RF reception and transmission: a random low-altitude orbit, a stationary 24-hour orbit, and a low-altitude "regularized" equatorial orbit.

Bell Telephone Labs advocates the random low-altitude orbit for putting a reliable commercial system into operation in the shortest time. It would use 30-50 satellites spaced at irregular intervals in a polar or nearly polar plane about 800-3000 miles above the earth. Each satellite would be spin-stabilized and contain a dipole antenna (*Fig. 1*). The spin would be imparted during launch, so that the satellite would always, like a gyro, point in the same direction relative to space. The spin orientation could not be used to keep the satellite antenna pointed directly at the earth, because the direction from the satellite to the center of the earth would change as the satellite revolved around the earth.

Three satellites would be enough

The 24-hour, earth-synchronous orbit whose plane includes the equator, requires an altitude of 22,300 miles. Because of this high altitude, only three equally spaced satellites would be needed to cover the entire earth. Most of the groups that have studied the problem of global satellite communications agree that this orbit is the "ultimate" answer. Though some of these groups do not believe that a reliable 24-hour system is feasible within the near future, others—including the Army, General Telephone, Hughes, ITT, Lockheed, and RCA—do and propose that we start right away with the "ultimate" synchronous system.

TIMETABLES for low- and high-altitude communications satellites as calculated by J. D. Sailor, of Lockheed Missiles & Space. For the low-altitude system (800 miles or higher), four satellites per booster and one failure in four launches are assumed; for the high-altitude system (up to 22,300 miles), a spare satellite and one failure in three launches. (The shaded portions of the bars show the range from earliest to latest possible completion.)

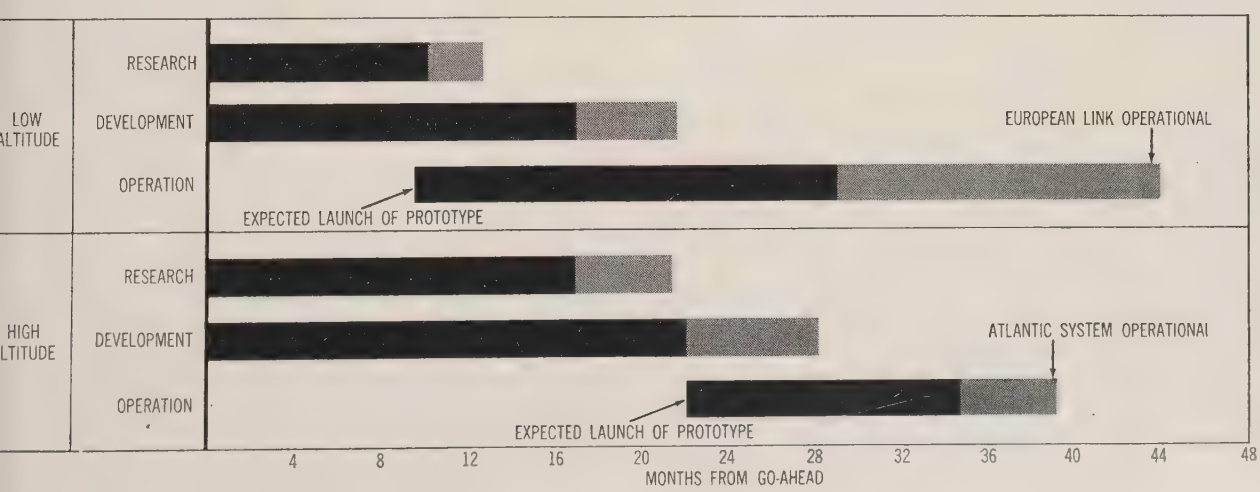


Table II: Characteristics of Space Communications Services[1]

Purpose	Service	Medium	Bandwidth per Channel		Estimated U. S. Demand for RF Channels
			Intelligence	RF[2]	
Heavy-route, long-haul commercial	2-way telephone, teletype, data, TV	active satellite relay	1-5 mc	20-100 mc	16 (shared by 13 terminals)
Medium-route, long-haul military	2-way telephone & data for military command	active or passive satellite relay	up to 1 mc[3]	up to 20 mc[3]	80 (in near future)
Mobile long-haul military	2-way communication between command centers & aircrafts or ships	active satellite relay	up to 50 kc[3]	up to 1 mc[4]	several nets (in near future)
Mobile commercial	2-way service between fixed terminals & aircraft or ships	active satellite relay	10 kc	200 kc	many nets
Mobile short-haul military	battlefield communications between command posts & vehicles	active or passive satellite relay	up to 100 kc[3]	up to 2 mc[4]	many nets in continental theater

(1) Calculated by Bell Telephone Labs. (2) For one path through the atmosphere. (3) May actually be much lower to preserve secrecy. (4) Excluding anti-jam features.

The low-altitude "regularized" equatorial orbit is proposed by GE. At about 8000 ft altitude, 10 equally spaced satellites would be required for global coverage. Attitude stabilization and position-keeping would be needed by both this satellite and the 24-hour type.

Of these three orbits, the random low-altitude type is the easiest to achieve. An available booster, the Thor-Delta, could be used, at a cost of about $3,500,000 per launch. The total cost of launching the 30-50 satellites needed for this type of orbit would be very high, but on the other hand a faulty satellite would be relatively cheap to replace. Other advantages lie in the low RF power requirement per satellite and the redundance of a large number of satellites.

A major drawback is the marginal operation that would result from the use of a low-powered RF output device and a non-directional antenna (as proposed by Bell Labs). An almost isotropic radiator would be essential, because of Bell Labs' reluctance to include attitude stabilization and risk more reliability and weight problems. However, Bell Labs is studying the stabilization problem and may very well include attitude control in later satellite designs.

Perhaps an even greater disadvantage of the random low-altitude orbit is the complex ground equipment needed for tracking, communications, and message switching. The communications ground station would have to have at least two antennas, each of which would have to follow each satellite from horizon to horizon. The station also would have to have a computer to enable the antennas to acquire the satellites and to solve the switching problems.

Furthermore, a special tracking station with a large computer would be needed to determine continuously the orbital characteristics of each satellite. These would be fed to the communications station's computer to generate the antenna positioning commands for satellite acquisition.

All the problems of the low-altitude, random-orbit system can, however, overcome by techniques already at hand. This system might not be the best in the long run, but it appears to be the easiest to put up right now.

The key advantages of the 24-hour orbit are that it requires only three satellites and that these would be fixed relative to the earth. The problems of switching, tracking, and antenna pointing therefore would be much simpler, and the ground station would cost a good deal less.

How to get a payload of reasonable size (several hundred pounds) into the 22,300-mile equatorial orbit in the correct position is the major problem of the 24-hour orbit. None of today's boosters can do the job—unless a site near the equator were used, and there is no such site so far.

Other drawbacks of the 24-hour synchronous orbit lie in the need for attitude stabilization (a directional antenna is essential) and for position-keeping. Should a satellite fail, a third of the system would be out until a replacement satellite could be shot up. (Such a breakdown could be forestalled by launching two satellites for each position—at a considerable increase in system cost.) A further, formidable problem is the disturbing echo that would arise during the relatively long time the signal would take to go from its point of origin to the satellite and down to its destination (see *Box*).

The low-altitude "regularized" equatorial orbit shares many of the advantages and disadvantages of the 24-hour synchronous orbit. It requires less powerful boosters, however, and doesn't have the echo disadvantage for single-hop transmissions.

1-8-kmc region is most desirable

Atmospheric attenuation, Faraday rotation, noise, and the available components make the 1-8-kmc region about the most desirable for a satellite communications relay. As we've already noted, different frequencies would be used for the up- and down-links.

Internationally, no allocations have yet been made

r space communications (except for space research in e 1700-1710- and 2290-2300-mc regions. In the U. S., :c has given permission for space experiments in the ound microwave relay bands. The Electronic Indus- ies Association has recommended that the U. S. Table Allocations be amended so that government and ivate companies could share the 1700-2700-, 3500- 200-, 4400-5000-, 5650-8500-, and 10,550-13,250-mc nds for satellite communications systems.

Estimates of the bandwidths needed for commercial mmunications satellites run from about 500 to 1600 c. This would allow for 600-1000 telephone voice annels, a television channel, and a wide-band modu- tion system. GE says it would need 335.2 mc of andwidth for the ground-to-satellite path and 500 mc r the satellite-to-ground path. Bell Labs told FCC at 320-1600 mc of bandwidth would be needed to eet the U. S. demand alone (*Table II*).

Choice of modulation is critical

Engineers rate the choice of modulation as the most itical element in the design of a communications atellite system. Several methods have been suggested:

- SSB-AM for the up-link and wide-deviation PM for he down-link (by Hughes Aircraft);
- SSB-AM for the up-link and FM for the down-link by General Telephone);
- wide-deviation FM with feedback (by Bell Labs);
- wide-deviation FM without feedback (by General Electric);
- PCM-FM (by ITT);
- SSB-AM for the up-link and FDM-FM for the down- ink (by RCA).

Henri Busignies, vice president and general technical irector at ITT, described the basis for the choice of modulation in a brief submitted to FCC when he pointed ut that "the most important consideration in selecting modulation technique is to minimize the power adiated from the satellite while maintaining a given S/N at the receiver output. In this case a wide-band- vidth modulation operating near its threshold is indi- ated. The bandwidth can then be adjusted to promote minimum radiated power for the desired S/N within he practical limitation of feedback circuit performance nd spectrum occupancy."

FM, PM, and PCM all let you trade bandwidth for ower and so improve S/N. This bandwidth-power radeoff—which holds considerable advantages for a atellite communications system, because of the power imitations of the satellite transmitter—is based on Shannon's work on information theory. Shannon points ut that, by going to a wider band signal, you can mprove S/N without increasing the transmitter power. (To explain this, you might say that the noise is averaged over a wider band.)

The wide-deviation FM schemes developed by Bell Labs, GE, and Hughes all are based on Shanon's work.[3] Bell Labs plans to use an FM system with a five-mega- cycle baseband and a 30-40-mc swing. To overcome he fact that more noise enters a wider-band receiver— which therefore will "break" sooner (when the output f the discriminator is more noise than signal)—it uses a special feedback loop that keeps the receiver tracking he transmitted frequency as the transmitter is modu- lated. The result is that the incoming signal, though it enters a wide-band channel, sees only a narrow pass- band. The feedback arrangement provides an im- provement of about six decibels that is almost inde- pendent of the swing over the wide band.

One of the disadvantages of FM for satellite com- munications lies in the capture effect—if the receiver sees two signals on the same frequency, it will either select the stronger signal or put out no intelligible sig- nal at all.

General Telephone, Hughes Aircraft and RCA pro- pose an SSB-AM link from the ground to the satellite in order to save bandwidth. The other proposals stay clear of AM because of the linear receiver it would require in the satellite. One of the roughest problems in any communications system design, they point out, is getting linearity for a number of channels.

PCM, if it is used for television, would call for a siz- able bandwidth. Assuming a five-megacycle baseband, each PCM digit would require 10 mc of bandwidth. This works out to 70 mc for a seven-digit system, which is about what would be needed for good video.

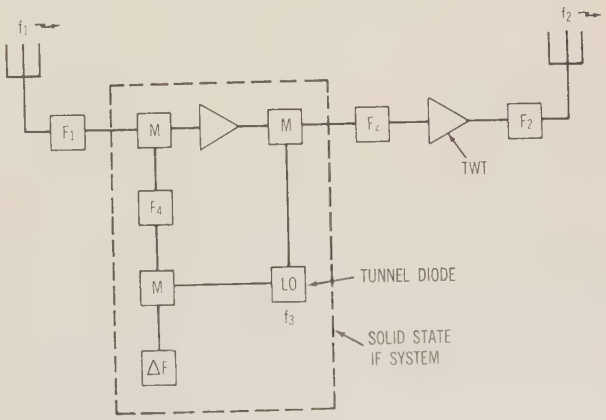
Figure 2 shows a repeater suggested by Bell Labs, which would be a solid-state design except for a TWT. The upcoming signal goes directly from the antenna to a converter, whose output is a 90-mc IF signal. After amplification at the intermediate frequency, the signal is modulated back up to the microwave output frequency (around 4000 mc) in a parametric up- converter. Then it is amplified in the TWT for trans- mission.

Some form of temperature control will have to be used to keep the satellite-borne equipment within its operating range. Advent will use a system of louvers that reportedly will expose coatings of different ab- sorbitivity-emissivity ratios. Other systems would use highly conductive thermal paths to the satellite shell, from where heat would be conducted through the skin and radiated into space.

Command and telemetering equipment will also be included in the satellite electronics package. Undoubted- ly, this will lead to many circuit sharing designs to cut weight and power.

As we've noted, a directional satellite antenna re- quires satellite stabilization about three axes—and there

FIGURE 2: Simple satellite-borne repeater proposed by Bell Telephone Labs for space relay experiments would be feasible if it proved possible to use tunnel diodes or tran- sistor harmonic generators as 6000-mc local oscillators.



(3) Hughes actually uses wide-deviation PM, but this scheme is very close to wide-deviation FM.

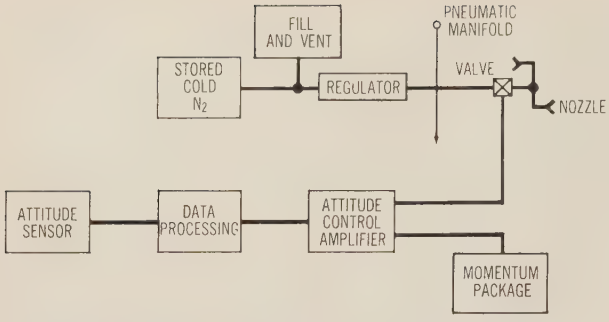


FIGURE 3: Attitude control system proposed by GE.

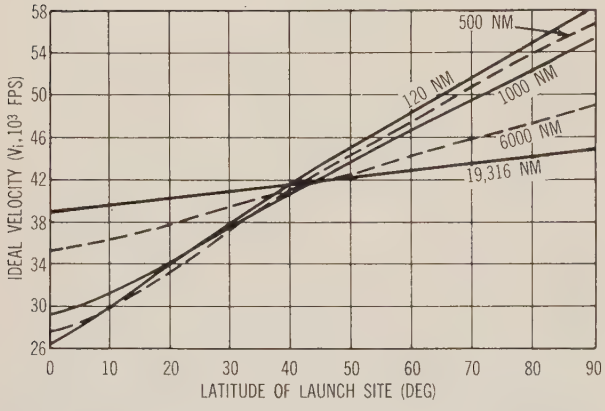


FIGURE 4: Ideal velocity for circular orbits at various altitudes.

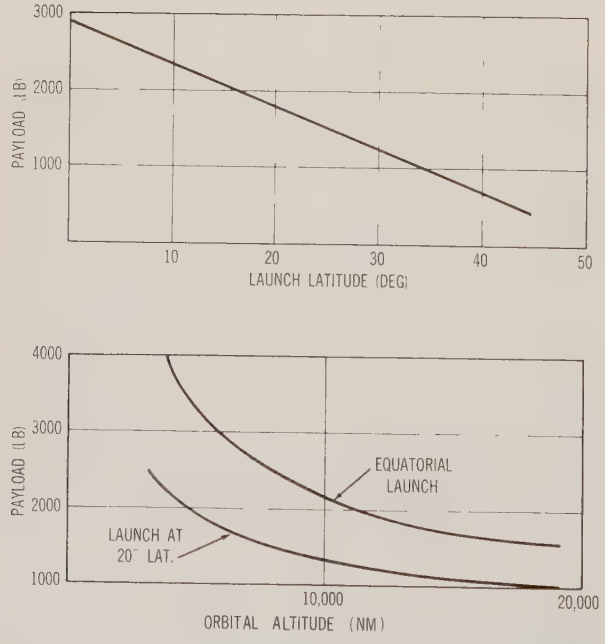


FIGURE 5: Payload vs launch latitude and orbital altitude for satellites launched by a hypothetical booster weighing about 300,000 lb at takeoff and using liquid oxygen in the top stage.

is no stabilization system that has proved its long-time reliability. Most of the stabilization methods that have been proposed for communications satellites rely on IR and/or optical sensors. Lockheed suggests pitch and roll sensing with IR horizon scanners and yaw sensing for directing gas jets with a sun-position indicator. Both these types of sensors have been used successfully in a number of satellites. Gravity-gradient and magnetic-moment sensors are also being considered, as is a mercury loop and electromagnetic pump system.

Sensed errors in attitude could be used to calibrate an inertial system that in turn drives a torque wheel, or to actuate gas jets. GE has proposed a relatively simple system that would use an IR sensor, a flywheel, and gas jets, and weigh about 160 lb (*Fig. 3*).

J. D. Sailor, of Lockheed Missiles & Space, calculates that a 24-hour satellite would have to be held within two degrees of the local vertical in pitch and roll to get the desired gain from a 25-deg-beamwidth communications antenna. He doubts whether spin stabilization alone would be effective for a five-year satellite carrying a wide-beam dipole antenna—some method of spin renewal or magnetic torquing, he believes, would have to be used to keep the satellite within the beam limits of the dipole by counteracting the disturbing forces produced by solar pressure and interaction with the earth's magnetic field and the regression due to inaccurate orbit injection. By itself, he claims, spin stabilization would be enough only if the satellite were injected into a nearly perfect polar orbit, with its spin axis aligned normal to the orbit plane. This appears well-nigh impossible at today's state of the guidance art.

Gas would supply power

R. P. Haviland, of GE's Missile & Space Vehicle Division, takes issue with the argument that, if gas jets are used for attitude control, their life would limit the whole satellite system. A few cubic feet of gas, he claims, would supply enough power for attitude control, position-keeping, and solar paddle pointing to keep the satellite proposed by GE operating for three years. He also says that, though an attitude control system might double the complexity of a payload, it would cut the weight of the power supply to a quarter of what it would be otherwise.

For a satellite that is to be put into any kind of "regularized" orbit with respect to the earth, position-keeping is needed. Since any variation in the satellite's orbit results in a variation in velocity, position-keeping amounts to making velocity corrections.

As the forces on satellites in space are not expected to be large, precise orbit injection minimizes the problem of position keeping. GE says it could put its satellites into their 8000-mile equatorial orbits so that, after two months of position-keeping, the satellites would need no further position control to remain in orbit for five years without exceeding their allowable drift. During the position-keeping period, it claims, the orbit corrections would amount to about 10 fps on the average and 50 fps maximum.

For the 24-hour stationary orbit, Lockheed believes that a velocity increment of several hundred fps per year may be required. There will be two types of orbital deviations, Lockheed explains: the daily deviation caused by orbit eccentricity and inclination and the long-term drift caused by orbit perturbations. No

attempt would be made to correct the inclination of the orbit plane, since all the accumulated errors it can lead to within a year will not exceed a 10-deg tracking antenna arc.

Position-keeping could be done in a variety of ways, using satellite-borne sensors (to telemeter data to ground computers that would generate correction commands) and ground tracking stations. Gas jets would be used for generating the corrective forces.

As we've noted, the sophisticated designs in the communication satellite systems will be reserved for the network of ground stations. Low-noise receiving systems, including antennas with very low back and side lobes and either parametric-amplifier or cryogenically cooled maser preamplifiers, will be standard. The complexity and cost of the ground station increases in some fashion with the height and "regularization" of the orbit. Very probably computers will be installed at central control stations to determine continuously the orbital parameters and select the correct circuits for communications. If SSB is used, either a central reference frequency would have to be fed to all ground stations or each station would have to be equipped with a very precise reference frequency generator.

Table I shows that most of the boosters likely to be used for launching communication satellites will not be ready for some time. Certainly there is no U. S. booster that could lift the several hundred pounds required by a stationary satellite into a 22,300-mile equatorial orbit from Cape Canaveral, Fla. (Lockheed maintains, though, that this job could be done by its Atlas-Agena if a solid-propellant rocket like Aerojet's 30KS8000 were added as the final stage.

As explained by Haviland, the propulsive energy required to place a given weight in orbit can be defined in terms of the ideal velocity of the rocket:
$V_i = V_{TO} + V_{ADJ} + V_{GRAVITY} + V_{DRAG} - V_{ROTATION}$,
where V_{TO} is the takeoff velocity required to get into the desired orbit and V_{ADJ} the adjustment velocity required to stay there. A synchronous satellite in an equatorial plane, for instance, requires an ideal velocity of 39,100 fps, while a 6000-mile-high satellite in the same plane requires only 35,600 (*Fig. 4*).

For any orbit, furthermore, higher ideal velocities are required if the launch site is not in the orbit plane than if it is. *Figure 5* shows this situation in terms of the payload of an equatorial satellite using a hypothetical booster of given thrust: from an equatorial site, nearly 3000 lb could be launched; but from Cape Canaveral only about 1000 lb.

Restartable rocket needed

To achieve an equatorial orbit after launch from Cape Canaveral a "dog leg" course would have to be followed. The minimum-energy trajectories for such a launch would involve a low-altitude "parking" orbit, a transfer ellipse, and finally injection into the desired orbit. A restartable rocket would have to be fired for each of the two trajectory changes (*Fig. 6*).

The guidance requirement for the transfer orbit appears to be quite stiff. The only somewhat similar orbit known to have been flown was followed by Midas III. This satellite was first put into an elliptical low-altitude parking orbit and then given a "kick in the apogee" by restarting its Agena-B rocket at the apex of the ellipse. How closely it came to this planned orbit has not been revealed and neither have any details about its guidance.

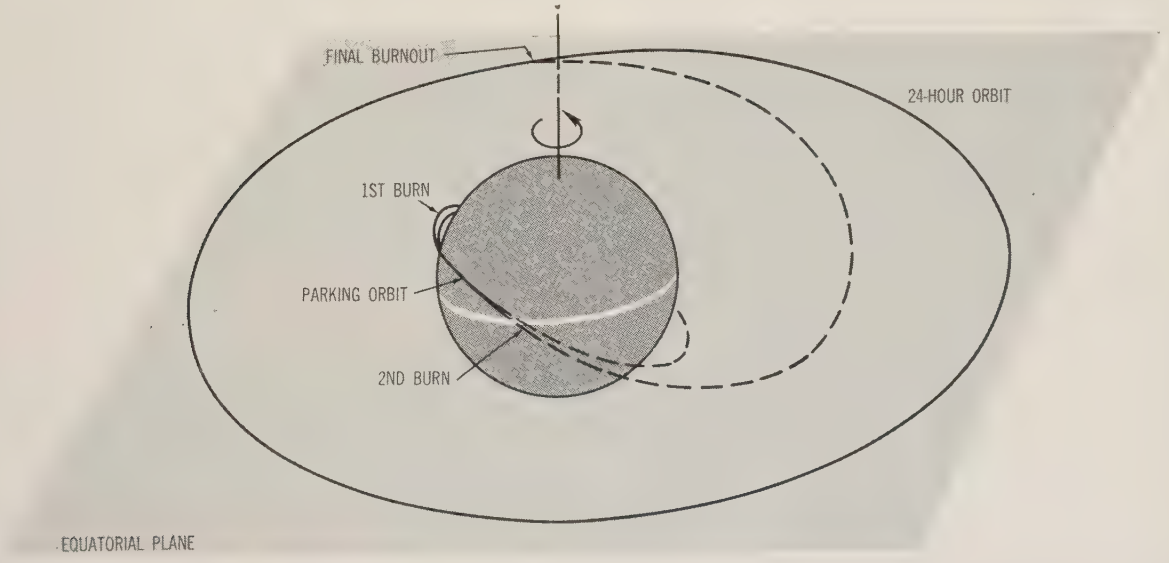


FIGURE 6: Its Atlas-Agena, topped off with an Aerojet 30KS8000 or some similar solid-propellant rocket, could boost a satellite into an equatorial, earth-synchronous orbit, says Lockheed Missiles & Space. The Atlas would boost the Agena containing the final stage and the payload to an altitude of 100 miles. The Agena engine would then be fired to place the vehicle in a slightly elliptical parking orbit. The vehicle would remain in this orbit until the earth had revolved to a specified position. Then, when the vehicle crossed the equatorial plane, the Agena would be restarted to achieve an inclined transfer orbit with its apogee at 22,300 miles. The third stage would be separated and coast to this apogee in 5.3 hours. At the apogee, the final stage would be yawed and the solid-propellant rocket fired to make the orbit circular and remove the inclination to the equatorial plane. Final corrections would be made by the satellite's own position-keeping system on command from ground trackers.

by A. D. Kraus, Research Engineer,
Sperry Gyroscope Co.*

Efficient heat transfer:
key to reliable airborne electronics

AS AIRBORNE electronic equipment becomes smaller, it becomes harder to keep cool. Equipment for which external cooling was once hardly a problem, now, after miniaturization, requires refined cooling systems if it is to operate reliably.

Vacuum tubes, for example, have shrunk in weight and volume and have now reached the subminiature stage, but their heat release and heat flux have gone up sharply. Transistors are the keystones of miniaturization, and they are also at the bottom of the temperature control problem. To use them properly, you have to be well versed not only in semiconductor theory but in heat-transfer concepts as well.

It is quite clear that component reliability is closely related to—if not largely dependent on—efficient heat withdrawal. Indeed, one of the main causes of poor reliability in today's electronic systems is inadequate heat removal, which leads to high operating temperatures. Experimental studies have shown that the failure rates of electronic components—vacuum tubes, semiconductor devices, resistors, capacitors, relays, switches, transformers, rotating devices—are directly proportional to the temperature at which these components operate.

Though the primary goal of cooling is to insure a component operating temperature consistent with reliability, we must also take into account the compatibility of the coolant and cooling system with the vehicle system. Otherwise you may lose in the design of the cooling system what you gained by miniaturization of components in the first place, which would amount to a clear-cut violation of the basic concept of least penalty to the vehicle. In addition, the cooling-system designer must pay attention to thermal packaging, adequate heat transfer from the exterior of enclosed assemblies, temperature and coolant control, overheat protection, and transient operation of his components and cooling system, as in warmup periods.

* Sperry Gyroscope Co., Great Neck, N. Y.

IN BRIEF

The nearly universal use of transistors in airborne electronics, which has come about as the logical result of the growing demands for miniaturization, has made temperature control one of the electronic designer's most serious problems. It actually has made it necessary for him to know as much about heat-transfer concepts and techniques as about semiconductor theory.

This article describes conduction, convection, and radiation, the three modes of heat transfer, as well as heat transfer by phase change in the boiling process (a special case of convection). In each case, the basic equations are analyzed with which the designer must work. As an example of how the concepts of heat transfer are used, the design of a forced-cooled electronic chassis is reviewed. A second article in this series will appear next month and will review further applications of heat transfer. It will also present actual cooling analyses for typical components and configurations used in current airborne equipment.

There are three modes of heat transfer (which is what cooling amounts to): conduction, convection, and radiation. Conductive heat transfer occurs when there is a difference in temperature between points in the same body or when two bodies at different temperatures are in contact. Under steady-state conditions, the flow of heat (q) is proportional to the area of the path (A), and the temperature gradient (dT/dx):[1]

(1) $$q \propto A dT/dx.$$

By inserting a proportionality constant you get:

(2) $$q = -kA dT/dx \ btu/hr,$$

where the proportionality constant (k) represents the thermal conductivity of the material constituting the heat flow path.

Equation 1 expresses the conductive process, or Fourier's Law of Heat Conduction. The negative sign shows that, in accordance with the Second Law of Thermodynamics, the heat flow is in a direction of falling temperature gradient.

The general differential *Equation 2* can be solved for specific configurations by separating the variables and integrating between the limits at the boundaries. *Figure 1* shows four specific configurations and the corresponding relationship for the heat flow (Fourier's Law). In each case, the rather simple relationships suggest the use of an electrothermal analogy for calculating the conduction processes. To make the analogy, you apply the Fourier Law for n sections in contact and Ohm's Law for the flow of electricity. Of course you have to assume that each section has its own thermal conductivity (k) and thickness (L).

Fourier's Law for these n (plane) sections yields:

(3) $$q = A\Delta T / \sum_{i=1}^{n} \frac{L_i}{k_i}.$$

Ohm's Law, of course, is:

(4) $$I = E/R.$$

When you compare these two expressions, you find that the current, or flow of electrical charge (I), is analogous to q, the potential (E), is analogous to the thermal potential, or temperature difference (ΔT), and the resistance to the flow of current (R) is analogous to the resistance to the heat flow $\left(\sum_{i=1}^{n} (L_i/k_i)/A \right)$.

(1) Under "steady-state conditions," heat dissipation and temperatures don't vary with time. For the designer, this is the most important mode of operation, because in practically all cases the temperatures of transient periods (warm-up and the like) will not exceed those of steady-state operation.

Nomenclature

Conduction

A	cross-sectional area normal to heat flow path (sq ft)
E	electric potential (volts)
I	current (amps)
k	thermal conductivity (btu/ft-hr-deg F)
L	length of heat-flow path (ft)
q	heat flow (watts or btu/hr)
R	electric resistance (ohms)
T	temperature (deg F)
T_a, T_b	interface temperatures
T_2	minimum temperature
x	length coordinate (ft)

Convection

A	area of coolant passage (sq ft)
C	specific heat (btu/lb-deg F)
C_p	specific heat of coolant (btu/lb-deg F)
d	inside diameter in coolant passage (ft)
d_e	equivalent diameter of coolant passage (ft)
f	friction factor (dimensionless)
g	acceleration of gravity (ft/hr^2)
h	heat transfer coefficient (btu/sq ft-hr-deg F)
h_E	entrance loss (feet of fluid)
h_f	friction loss (feet of fluid)
h_{fg}	latent heat of vaporization (btu/lb)
h_x	exit loss (feet of fluid)
j	heat transfer parameter
k	thermal conductivity of fluid (btu/ft-hr-deg F)
L	length of coolant passage (ft)
q	heat flow (watts or btu/hr)
S	surface for heat transfer (sq ft)
T	temperature (deg F)
T_c	cold bulk temperature (deg F)
T_h	hot bulk temperature (deg F)
T_S	cold plate surface temperature (deg F)
T_{S1}	chassis temperature at inlet end
T_{S2}	chassis temperature at outlet end
T_1	coolant inlet temperature
T_2	coolant outlet temperature
V	coolant velocity (ft/hr)
w	flow rate (pph)
Δp	pressure loss (psi)
θ_m	logarithmic mean temperature differential (deg F)
μ	coolant viscosity (lb/hr-ft)
μ_w	coolant viscosity at temperature of contact surface (lb/hr-ft)
ρ	density of fluid under standard conditions (lb/cu ft)
σ	surface tension of liquid-vapor interface (lb/ft)
β	volumetric bulk modulus of expansion (1/deg R)

SUBSCRIPTS

a average E entrance L liquid
v vapor x exit

Radiation

E	Radiant heat emission (watts or btu/hr)
E_b	monochromatic emissive power (btu/sq ft-hr-micron)
e	Naperian base
F_A	arrangement factor (dimensionless)
F_ϵ	emissivity factor (dimensionless)
S	emitting surface (sq ft)
T	absolute temperature (degrees R)
ϵ	emissivity
σ	Stefan-Boltzmann constant (1.732×10^{-9} btu/sq ft-hr-deg R^4)
λ	wavelength of emission (microns)

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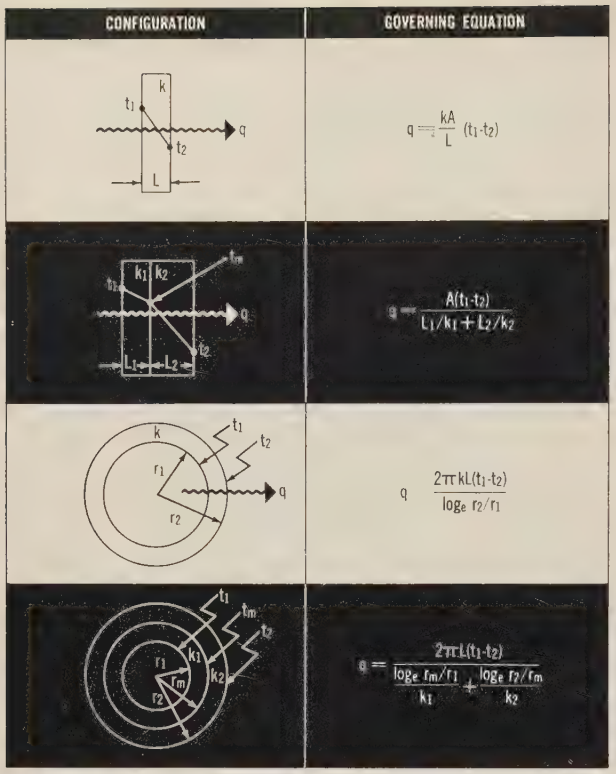

CONFIGURATION
GOVERNING EQUATION
$q = \frac{kA}{L}(t_1 - t_2)$
$q = \frac{A(t_1 - t_2)}{L_1/k_1 + L_2/k_2}$
$q = \frac{2\pi kL(t_1 - t_2)}{\log_e r_2/r_1}$
$q = \frac{2\pi L(t_1 - t_2)}{\frac{\log_e r_m/r_1}{k_1} + \frac{\log_e r_2/r_m}{k_2}}$

FIGURE 1: Heat-flow equations for various configurations.

Take, for example, the case of three slabs of material positioned "back-to-back" (*Fig. 2*). The electrothermal analog circuit for this case shows that the interface temperatures (T_a and T_b) are between the slabs and that the lowest temperature (T_2) is taken as ground potential. Obviously, this simple electrothermal analog circuit and others like it can be used to great advantage in quick and accurate calculations of steady-state heat flow and temperature differentials. It has also made it possible to apply some of the more elegant network methods provided by analysis theorems (mesh analysis, nodal analysis, the Thévenin theorem, the Norton theorem, superposition, etc.).

Convection can be defined as the exchange of heat between a surface and a fluid that results entirely from the intermingling of the portion of fluid adjacent to the surface with the remainder of the fluid—a mixing of a bulk fluid with elements or parcels of that fluid that are in contact with a confining or limiting surface. This process can occur in two forms depending on the method mixing or agitation:

- In *forced* convection, the flow of fluid is mechanically forced, or induced, by some external device like a fan, pump, or blower.
- In *free,* or natural, convection, mechanical agitation is produced by fluid density differences induced by the temperature differential between the portion of the fluid contacting the surface and the bulk of the fluid.

Because natural convection depends on differences in density, its effectiveness as a mode of heat transfer decreases sharply as altitude increases. Furthermore, it ceases to be a mode of heat transfer in the absence of gravity.

The convective heat flow is directly proportional to both the area of the surface normal to the heat-flow and to the temperature differential between confining surface and bulk fluid:

$$q \propto S\Delta T. \tag{5}$$

The proportionality constant in this case is the coefficient of heat transfer (h). If you apply this constant, you get:

$$q = hS\Delta T. \tag{6}$$

because it lets you construct the relationship expressed in *Equation 6*, h may be called a "constant." Actually it is far from constant. It is directly proportional to the density, velocity, thermal conductivity, and specific heat of the coolant and inversely proportional to the viscosity of the coolant and some significant dimension of the configuration involved in the heat transfer. In forced convection, furthermore, it is a function of the flow regime about the configuration. In most cases, it is higher for turbulent than for streamline or laminar flow.

Physical configuration all-important

The importance of the physical configuration for conductive heat transfer cannot be overstated. Heat transfer correlations are nearly always empirical, being based on test data for a particular experimental configuration. You can't, therefore, use a correlation for the flow within a pipe to evaluate the heat-transfer coefficient for a flow across a row of electron tubes. If you must start with a particular heat-transfer correlation, make sure that it is applied to a configuration identical to that from which the correlation was derived.

For instance, the heat-transfer coefficient for the flow of heat-transfer media (air, gas, water, oil, etc.) through a pipe, duct, or annular passage is:

$$h = 0.023(k/d)(\rho Vd/\mu)^{0.8}(C_p\mu/k)^{0.33}(\mu/\mu_w)^{0.14}, \tag{7}$$

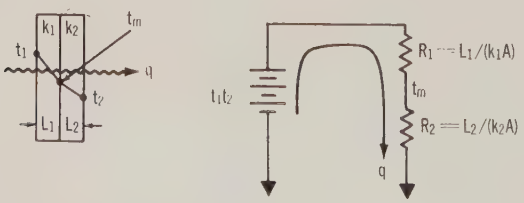
where the Reynolds number ($\rho Vd/\mu$) exceeds 2100 (turbulent flow). For laminar flow, when the Reynolds number is less than 2100, this correlation equatior becomes:

$$h = 1.86(k/d)[(\rho Vd/\mu)(C_p\mu/k)(d/L)]^{0.33}(\mu/\mu_w)^{0.14}. \tag{8}$$

Figure 3 can help in quickly figuring heat transfer coefficients. Extremely useful correlations have also been established for the flow over the external surfaces of staggered banks of tubes.[2]

As correlations for any particular configuration may not be covered in the literature, you must be prepared to obtain empirical data for yourself. This had to be done, for instance, for the axial flow of air through a

FIGURE 2: Back-to-back slab arrangement and electrothermal analog circuit.



(2) A. B. Colburn, "A Method of Correlating Forced Convection Heat Transfer Data and a Comparison with Fluid Friction;" *Trans. AIChE*, vol. 29, '33.

vacuum tube amplifier. Based on about 250 test points, the correlation for this case is:

$$h = 12.78\, C_p\rho V(\rho V d_e/\mu)^{-0.28}(C_p\mu/k)^{0.55}. \quad (9)$$

Heat-transfer coefficients for natural convection have also been correlated. Most of them turn out about like:

$$h = Ck(\Delta T/L)^n(a\beta^2)^n, \quad a = g\beta C_p\rho/\mu k, \quad (10)$$

where β is the volumetric bulk modulus of expansion in reciprocals of degrees; g, the acceleration of gravity (in. ft/hr^2); ρ, the density of the fluid at some standard condition; and p, the ratio of the actual fluid density to the standard one. *Table I* gives the values of C, n, and the characteristic length (L), for a number of cases.

The electrothermal analog circuit can also be used to describe systems relying on either forced or natural convection. The thermal potential and heat flow are exactly the same as in the case of conduction and are handled similarly. The resistance to the heat flow is now convective and can be represented as $1/hs$.

Figure 4 shows the three-layered slab of *Figure 2*, but with convective resistances at both outer faces. In the analog circuit, the bulk temperatures are given as T_h and T_c (hot and cold, respectively). The value for q and the temperatures T_1, T_a, T_b and T_2 do not necessarily correspond in magnitude to those for *Figure 2*.

The boiling of a liquid—a convection process involving the change of phase from a liquid to a vapor—has recently been adopted for applications in which high heat fluxes must be dissipated at low temperature differentials or potentials. The phenomenon of boiling is characterized by very little resistance to the flow of heat in the nucleate region, because vapor bubbles appear so quickly that they produce intense turbulence near the heated surface.

Figure 5 shows a heat flux pattern as a function of temperature differential for pool boiling. This type of pattern occurs when a flat surface is heated and the liquid above the surface is not mechanically agitated. The temperature differential in this case is that between the temperature of the heated surface and the saturation temperature of the liquid.

Bubbles aid convection process

The natural convection regime in *Figure 5* extends from A to B. At B, vapor bubbles begin to form and the heat flux begins to increase sharply with small temperature rises (since the bubbles aid the convection process). Throughout the nucleate boiling regime from B to C, the heat flux increases as bubble formation becomes more violent.

At C, the heat flux peaks, and from now on, the bubbles tend to interfere with one another and a film gradually covers the surface. This point C, called the burnout point because the film adds resistance and a considerably higher temperature differential is required, marks the beginning of the film boiling regime. From D to E, the film boiling regime is stable, but eventually the theat flux builds up to the level of C as radiation becomes significant (F).

The boiling liquid yields enormous heat flux values at low temperature differentials. The designer, of course, must try to confine the operation of a boiling-heat-transfer system to the nucleate boiling regime. An in-

FIGURE 3: Heat transfer to a fluid flowing in a duct, where j equals (hd/k) $(C_p\mu/k)^{-1/3}$ $(\mu/\mu_w)^{0.14}$. At Reynolds numbers below 2100 (laminar flow), j is a function of the passage's ratio of length to ID (for which several values are shown). For gaseous coolants, $(\mu/\mu_w)^{0.14}$ can be assumed to be unity.

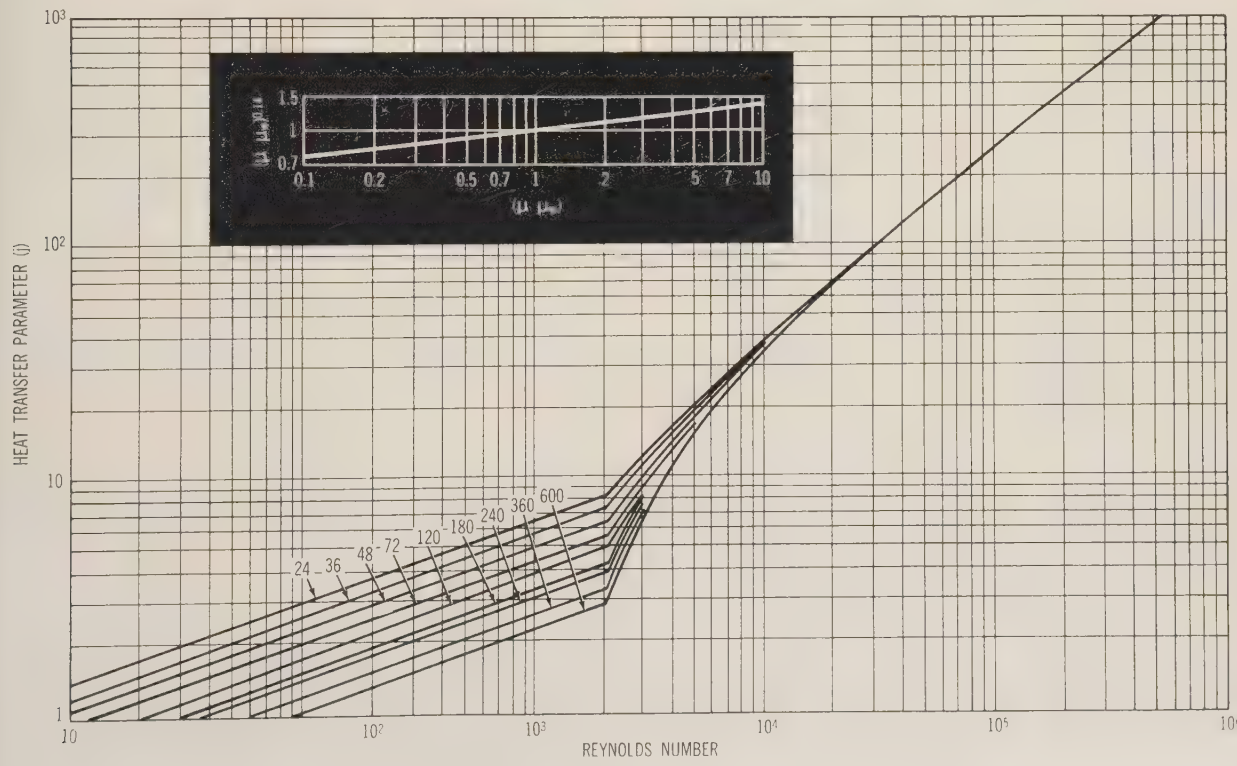
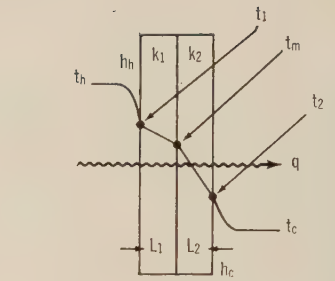


Table I: Constants n and C for Natural Convection

Body	Significant L (always ≤ 2 ft)	$aL^3\theta < 10^9$		$aL^3\theta > 10^9$	
		n	C	n	C
Vertical plane:	height, unless horizontal dimension is five times greater, in which case: $1/L = 1/L_{vert} + 1/L_{horiz}$	0 25	0.55	0.333	0.13
Sphere	radius	0.25	0.63	0.333	0.15
Horizontal plates	width (smaller of the two length dimensions)				
Facing up		0.25	0.71	0.333	0.17
Facing down		0.25	0.35	0.333	0.08
Cylinders					
Horizontal	diameter, unless it is five times greater than the horizontal dimension, in which case: $1/L = 1/\text{dia.} + 1/L_{horiz}$	0.25	0.45	0.333	0.11
Vertical	height, unless diameter is five times greater, in which case: $1/L = 1/\text{dia.} + 1/L_{vert}$	0.25	0.50	0.333	0.12



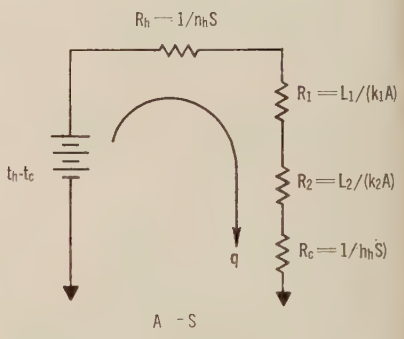


FIGURE 4: Back-to-back slab arrangement with convective resistances at both outer faces.

crease in heat flux beyond point C will result in a temperature jump to F that could destroy the surface that is being cooled.

Though not nearly as much is known about boiling as about single-phase convection, several correlations have been established, such as the one for pool boiling:

$$(11)\quad C_L\Delta T/h_{fg}(C_L\mu_L/k_L)^{1.7} = A\left(\frac{q/s}{\mu_L h_{fg}}\sqrt{\frac{4.17\times 10^8\sigma}{g(\rho_L-\rho_v)}}\right).$$

where A is a constant. According to this equation, boiling under gravity-less space conditions should require an infinite temperature differential for boiling. Nevertheless, studies show that boiling does take place in zero-gravity. Correlations for this condition are lacking so far but can be expected for the not too distant future.

Inadequate theory for radiation

Radiation is probably the least understood of the three modes of heat transfer. In fact, we still don't have a theory for the mechanism of thermal radiation that takes into account all aspects of the phenomenon. Many observations, however, have been best explained by the concept of the electromagnetic wave, since the mechanical theory of heat postulates that temperature is a reflection of the kinetic energy of the molecular particles of matter.

In emitting radiation, a body converts part of this internal energy into an electromagnetic wave. As the internal kinetic energy of a material is a direct function of its absolute temperature, it's obvious that the magnitude of the thermal radiation increases with the absolute temperature of the emitter.

The radiation from a heat source at a given temperature can be dispersed into a spectrum by a prism or some other suitable device. With sensitive measuring instruments, you can show that the energy within the spectrum is distributed over a range of wavelengths and that the variation of the monochromatic emissive power ($E_{b\lambda}$) is a function of the emitter temperature (*Fig. 6*).

Emissivity is used in practice

Planck, in formulating his quantum theory, derived the relationship between monochromatic emissive power, wavelength, and absolute temperature as:

$$(12)\quad E_{b\lambda} = \frac{1.16\times 10^8}{\lambda^5(e^{25740/(\lambda T)}-1)}.$$

By integrating between wavelengths of zero and infinity, you get the total monochromatic emission from an ideal radiator, or black body:

$$(13)\quad E_b = \sigma T^4,$$

where σ is the Stefan-Boltzmann constant and T the absolute temperature of emission.

Unfortunately, black bodies exists only as laboratory curiosities. We therefore must use the dimensionless property of emissivity (ϵ), which is the ratio of actual emission to the ideal emission of a black body at a

particular temperature. The total emission from a body then is:

(14) $$E = \sigma \epsilon S T^4,$$

where S is the emitting area.

When two bodies interchange radiant heat, both emit in accordance with *Equation 14*. If you're concerned with the heat transfer between a source and a receiver, therefore, you must account for the temperatures of each and the amount of heat each intercepts from the other. From *Equation 14* you can find the respective emissions of source and receiver as:

(15) $$E_s = \sigma \epsilon_s S_s T_s^4, \quad E_r = \sigma \epsilon_r S_r T_r^4$$

The net interchange of radiant heat is:

(16) $$q = E_s - E_r = \sigma F_\epsilon F_A S (T_s^4 - T_r^4),$$

where F_ε is an emissivity factor relating the emissivities of source and receiver and F_A an arrangement factor relating the placement and geometry of source and receiver (*Table II*).

In an actual design problem, you can use *Equation 2* for convection on a component-to-component basis, since it is an incremental equation—it applies to a convective process where the surface area for heat-transfer is small and Δt is the temperature difference between the surface and the average temperature of the coolant stream. But obviously it isn't meant to be used for configurations with relatively large heat-transfer surfaces.

Cold-plate design is widely used

Figure 7, which shows a cold-plate-type heat exchanger, makes this point quite clear. The cold plate is a forced-cooled electronic chassis using air or liquid as a coolant medium. This design has many proponents and is widely used for cooling all types of electronics. With even heat loading on the chassis (say, watts per square inch), you might find a temperature pattern similar to that in *Figure 7*, where t_1 and t_2 are the inlet and outlet temperatures of the coolant and t_{s1} and t_{s2} the temperatures of inlet and outlet ends of the chassis.

If you assume the heat-transfer coefficient to be constant over the entire chassis surface, you can express the flow of heat by the "rate" equation:

(17) $$q = hS\theta_m,$$

where θ_m is the logarithmic mean temperature difference. For the cold-plate temperature pattern you get:

(18) $$\theta_m = \frac{(T_{s1} - T_1) - (T_{s2} - T_2)}{ln(T_{s1} - T_1/T_{s2} - T_2)}.$$

At a low heat load and a fairly high heat-transfer coefficient the cold plate is essentially isothermal at temperature t_s, so that we can reduce *Equation 18* to:

(19) $$\theta_m = \frac{T_2 - T_1}{ln(T_s - T_1(/)T_s - T_2)}.$$

The design of a cold plate is relatively simple. Let's assume that you must apply a coolant fluid at a certain flow rate (w) and at temperature t_1 and that the heat dissipation and the allowable cold-plate temperature are given. For instance, t_s may be the chassis temperature required for reliable operation of the electronic components:

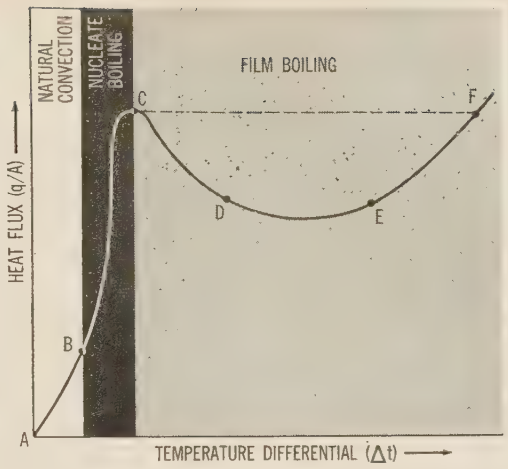


FIGURE 5: Heat flux vs temperature differential for pool boiling.

- From thermodynamic concepts, calculate the coolant outlet temperature:

(20) $$T_2 = T_1 + q/w\, C_p.$$

- From *Equation 19*, calculate θ_m.
- Select a passage configuration and determine the equivalent diameter (d_e), passage area (A), and surface area (S) for heat transfer:

(21) $$d_e = 2ab/(a + b), \quad A = ab, \quad S = 2(a + b)L.$$

- Determine the physical properties of the coolant fluid at the average film temperature:

FIGURE 6: Monochromatic emissive power vs emission wavelength for two emitter temperatures.

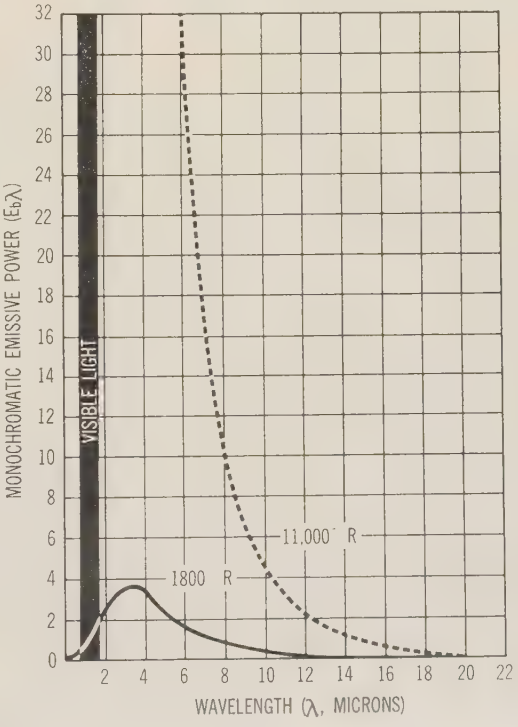


Table II: Factors for Radiation between Solids

Surfaces	Area, S	F_A	F_ϵ
Infinite parallel planes (S_1 and S_2)	S_1 and S_2	1	$\dfrac{1}{\frac{1}{\epsilon_1}+\frac{1}{\epsilon_2}-1}$
Body S_1 completely enclosed by much larger body S_2	S	1	ϵ_1
Body S_1 completely enclosed by slightly larger body S_2	S_1	1	$\dfrac{1}{\frac{1}{\epsilon_1}+\frac{1}{\epsilon_2}-1}$
Concentric spheres (S_1 inside S_2)	S_1	1	$\dfrac{1}{\frac{1}{\epsilon_1}+\frac{S_1}{S_2}\left(\frac{1}{\epsilon_2}-1\right)}$
Infinite concentric cylinders (S_1 inside S_2)	S_1	1	$\dfrac{1}{\frac{1}{\epsilon_1}+\frac{S_1}{S_2}\left(\frac{1}{\epsilon_2}-1\right)}$

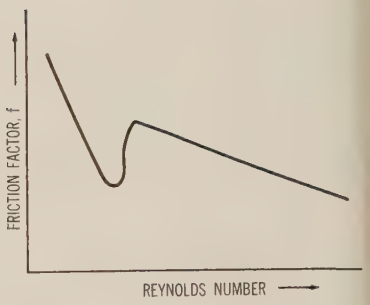


FIGURE 8: Friction vs Reynolds number.

(22) $$T_f = \tfrac{1}{2}\left[T_s + \tfrac{1}{2}(T_1 + T_2)\right].$$

- Determine h from *Equation 5* or *6*.
- Determine the required surface from *Equation 17*.
- Select the best arrangement of the surface consistent with installation and coolant pressure-loss requirements.

Radiative heat transfer has not entered into this analysis—at the temperature in question, radiation would be quite insignificant. It's good practice, however, to consider the small amount of radiation that does occur as a margin of safety for the analysis.

Pressure loss plays a significant role in heat-transfer equipment design. As heat transfer and friction go hand in hand, there is a loss of head as the fluid moves through the cooling system. You can make this loss work for you by designing your equipment so that the pressure head is dissipated in actual heat transfer and not in needless ancillary functions like the turning of the coolant stream.

For a "once-through" cold plate, you must deal with three losses—entrance loss (h_E), exit loss (h_x), and actual friction loss (h_f):

(23) $$h_E = 0.5V_E^2/2g, \quad h_x = V_x^2/2g, \quad h_f = fLV_a^2/2dg.$$

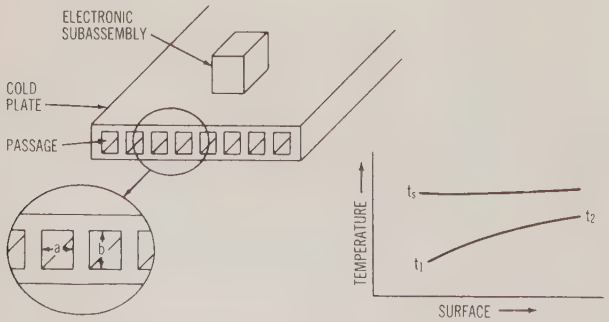
For flow inside a pipe, duct, or annulus, the friction loss can be represented by:

(24) $$h_f = \Delta p = fL\rho_a V_a^2/[8.37 \times 10^8 d(\mu/\mu_w)^n] \ psi,$$

where f is the friction factor, a function of the Reynolds number, and n is 0.14 for Reynolds numbers above 2100 and 0.25 for Reynolds numbers below 2100. Now you can calculate the pressure drop for the cold plate:

- Evaluate all other pertinent parameters, such as the entrance, exit and average velocities (V_E, V_x, V_a) and ρ_a.
- Evaluate f from *Figure 8*.
- Compute h_E and h_x and convert to the appropriate units.
- Compute h_f and convert to the appropriate units. (For instance, 0.0361 psi equals one inch of water.)
- Add up all pressure losses. If the total doesn't account for all the pressure in the system, the cold plate must be redesigned by trial-and-error balancing of the heat-transfer configuration with the pressure-loss calculations until all the available pressure loss is absorbed in heat transfer.

FIGURE 7: Cold-plate heat exchanger and its temperature pattern.



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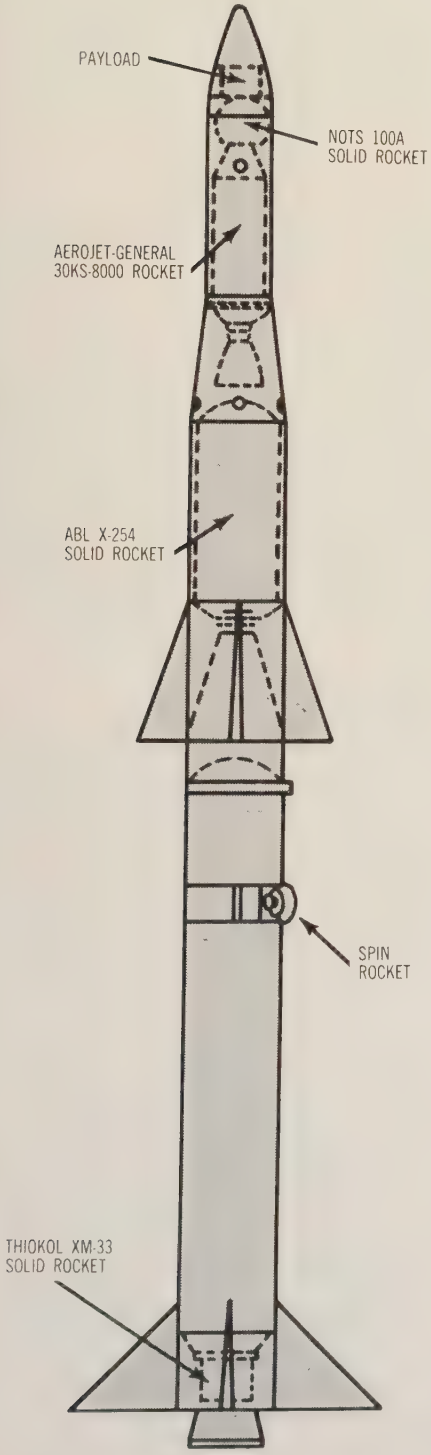
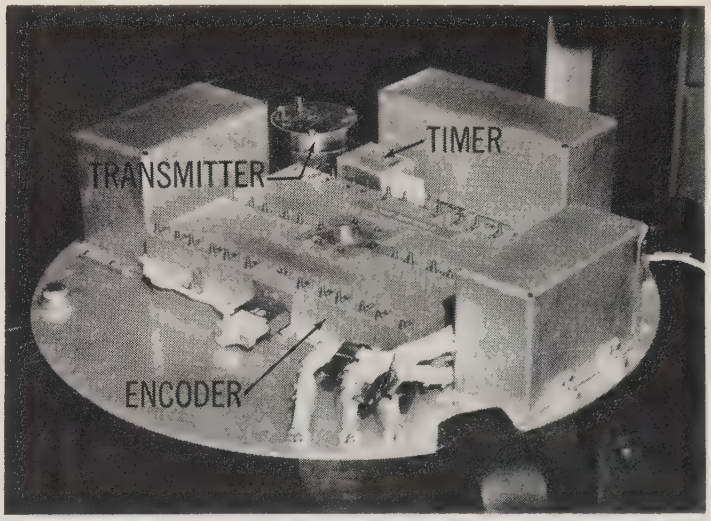
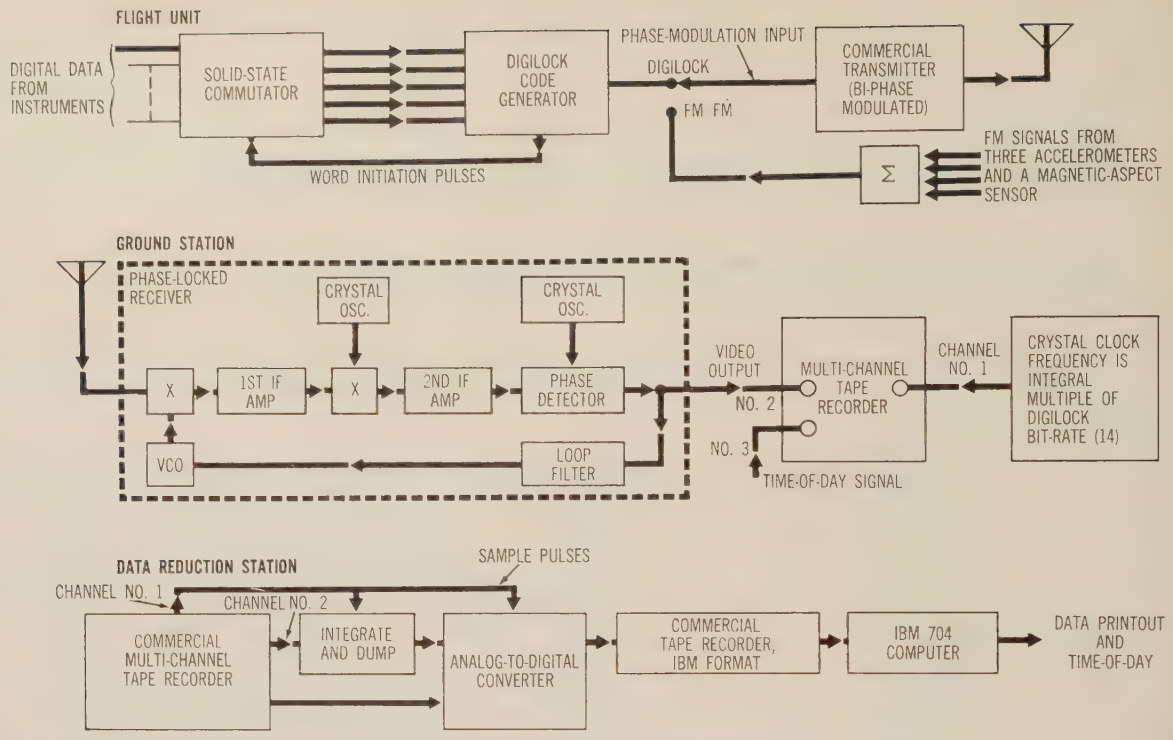


by Bernard Kovit, Associate Editor

DIGILOCK, a low power, phase-coherent, coded PCM telemetry system developed by Space-General Corp., Glendale, Calif., for USAF's Special Weapons Center, is designed to get maximum data return from radiation and magnetic-field probes at about 100,000 miles from earth. Its communications efficiency (watts/bit) approaches Shannon's theoretical lower limit. Where at least a 20-db S/N ratio used to be required, for instance, Digilock will make do with —12 db. In terms of power, this means a ¼-W Digilock transmitter could do as well as a conventional 400-W transmitter. The flight package is built around a 4.3-lb. encoder that converts data, computer-like, from the probe's instruments (100 binary inputs in groups of five bits each) into 16-bit Digilock words for transmission. The transmitted codes are bi-orthogonal, being based on the Reed-Muller codes, and can be unscrambled on the ground from signals that appear as almost pure noise at the receivers. Transmitter used is Vector's ¼-W TRPT-250R and the ground receivers will be 10 Nems Clark 1401B RF units modified by Space-General's phase-lock converter. Tracking-loop bandwidth is 20 cps; information bandwidth, three kilocycles. At launch, the transmitter is operated FM/PM with analog inputs from a three-accelerometer package and magnetic aspect sensor. Digilock PCM/PS operation is started after fourth-stage burnout. First job for this system is on USAF's Blue Scout Jr. space probe (range, 40-50 thousand mi; payload, 28 lb). Write in No. 54 on Reader Service Card for more information.



FLIGHT UNIT mounts on underside of sensor payload. Blue Scout, Jr. (left), is unguided, spin-stabilized, and uses no beacons. Trajectory is figured from azimuth, elevation, and time readouts at telemetry tracking stations.



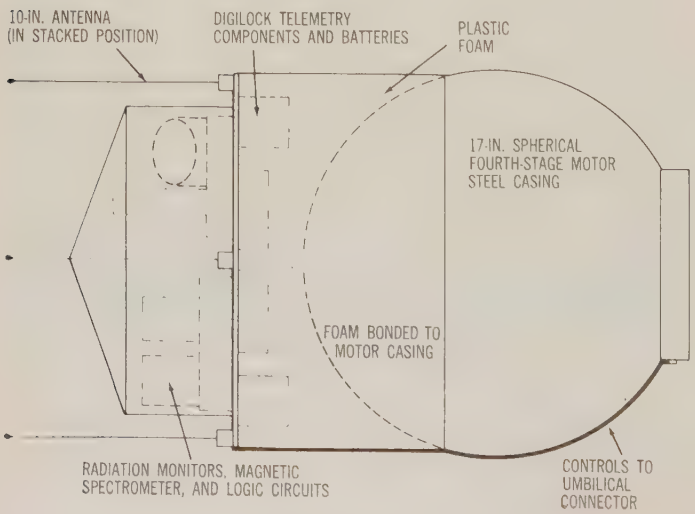
OVERALL SYSTEM: Flight unit: Commutator selects one of 20 five-bit words in line with pulses from code generator (CG). CG's 16-bit output, which corresponds to the value of the data input, bi-phase modulates an FM/FM transmitter by ±60 deg to get an unmodulated carrier plus constant-amplitude RF signal. This signal either leads or lags the carrier by 90 deg, depending on the value of the CG output at any instant. Ground station: As the loop bandwidth of the receiver is too narrow to follow the modulated carrier component, the Digilock sequences appear as binary voltages at the output of phase detector. These are recorded in analog form together with time-of-day signal and a clock signal that eventually triggers A-D converter. Reduction: During playback, the A-D converter yields 14 consecutive digitized samples for each Digilock bit received that are recorded together with time-of-day signal in IBM format. According to AFSWC, real-time data reduction is quite feasible for this system.

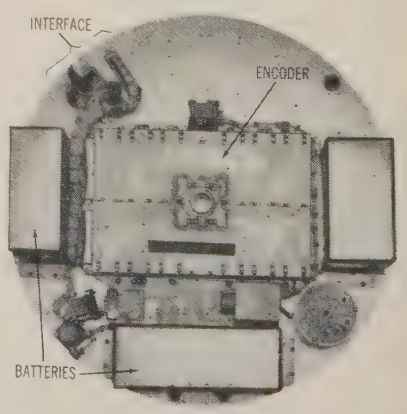
Flight Unit Specs

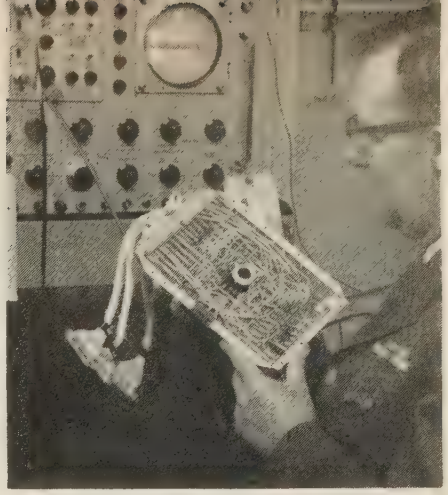
Digilock inputs	100 binary five-bit words
Type of codes used	bi-orthogonal (based on Reed-Muller)
Bit rate	214/sec (crystal-controlled to one part in 10^5)
Error rate	one in 10^6 (theoretical) at S/N ratio of −6 db

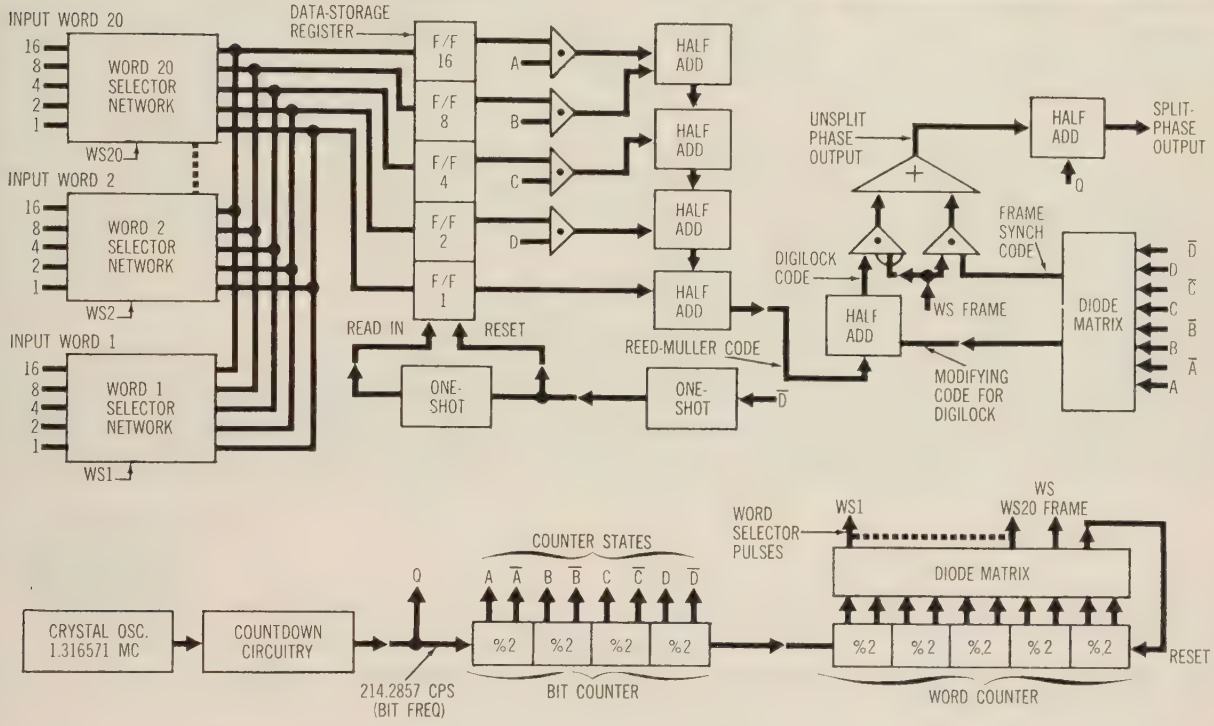
Weights (lb)	
Transmitter (250 mw)	0.44
Encoder	4.34
Batteries (28 V)	6.87
VCOs & accelerometers	0.94
Aspect sensor	2.0

BURIED in plastic foam, Digilock units mount on underside of payload housing base (left). Underside view (right) shows complete instrument-telemetry interface—three plugs. Diameter of base is about 17 in.


10-IN. ANTENNA (IN STACKED POSITION)
DIGILOCK TELEMETRY COMPONENTS AND BATTERIES
PLASTIC FOAM
17-IN. SPHERICAL FOURTH-STAGE MOTOR STEEL CASING
FOAM BONDED TO MOTOR CASING
RADIATION MONITORS, MAGNETIC SPECTROMETER, AND LOGIC CIRCUITS
CONTROLS TO UMBILICAL CONNECTOR

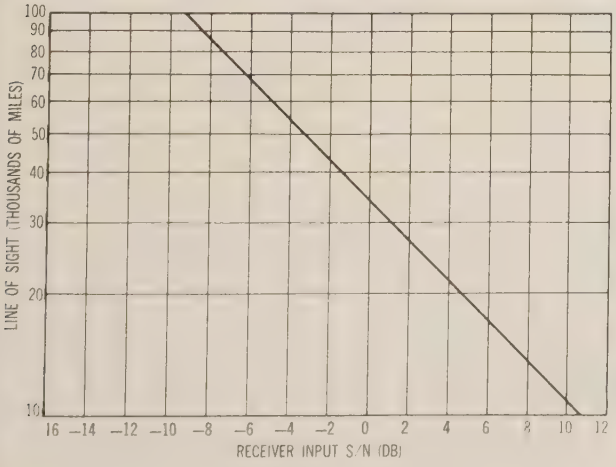


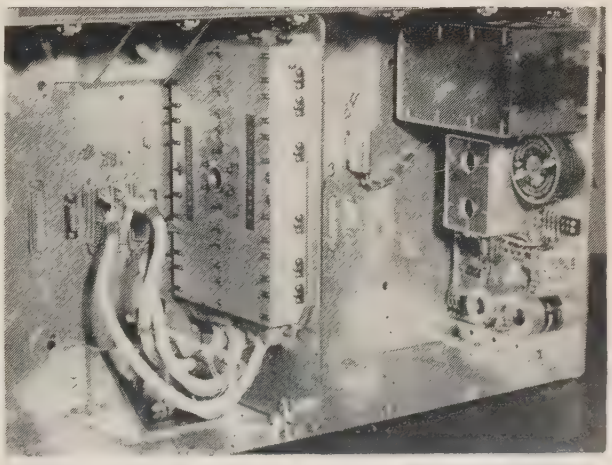


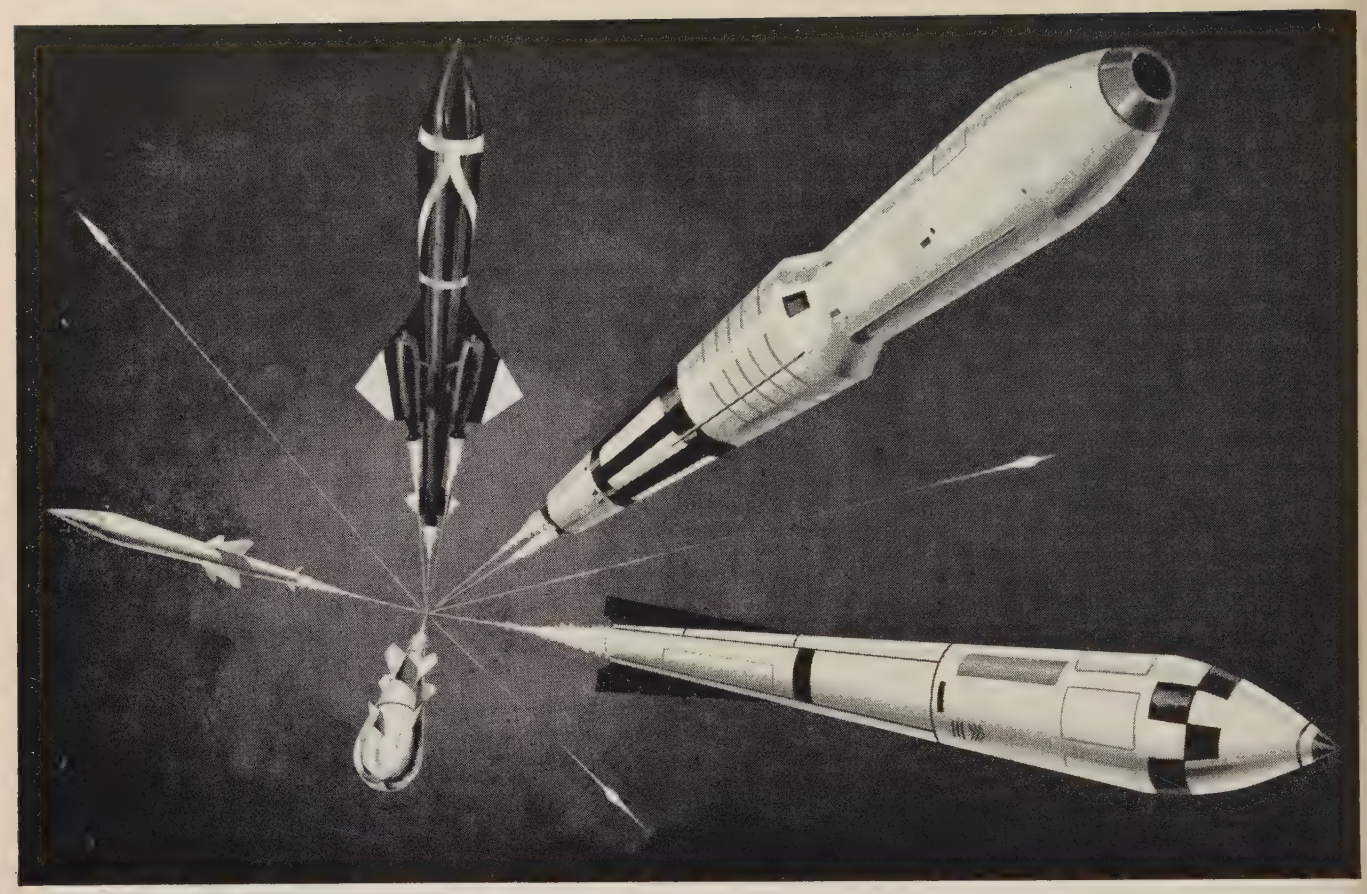


HOW ENCODER WORKS: Information bits in the data storage register are systematically combined in a series of AND gates and half adders to produce the basic Reed-Muller codes. This output is then half-added to a simple binary sequence to produce the Digilock code group. Combining the codes with a properly sequenced frame synch code and half-adding the combined output to the clock square wave gives the split-phase output sequence required to modulate the transmitter. Top: View of encoder circuitry and a complete 4.3-lb unit.

RANGE VS S/N RATIO: A 6-db increase in gain or quadrupling the carrier power would double the range. Right: Test installation in an Atlas with which increased bit-rate-to-receiver data reduction will be tried before the probe shots. For this test, the Digilock units must ride piggyback in the Atlas' external electronics pod.







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Cryogenic gyros

levitated by magnetic repulsion

by J. T. Harding and R. H. Tuffias, Research Scientists, Jet Propulsion Laboratory

THE DEVELOPMENT of inertial guidance systems depends on our finding methods to eliminate all unpredictable forces from the inertial element. In the gyro field, engineering techniques have been pushed almost to the limit in the search for mechanical rotor supports that minimize friction. A promising alternative to mechanical suspension is the use of the pressures set up by electromagnetic fields, or field levitation.

A well-known example of field levitation is the lifting of a piece of iron by a magnet. Not so well known are three other, recently developed levitation processes:

- the suspension of conductors by DC electric fields, or electrostatic support;
- the suspension of non-ferrous metals by high-frequency magnetic fields;
- the suspension of superconductors by DC magnetic fields.

All these techniques are applicable to gyros. Despite the constraints imposed by the fact that superconductivity is a cryogenic phenomenon, the superconducting gyro offers several significant advantages:

IN BRIEF

The torqueless suspension of a superconducting sphere is made possible by the fact that, in the Meissner effect, magnetic forces on a superconductor are exerted normal to the sphere's surface. Because of the lack of resistance, such a sphere furthermore can achieve high rotational speeds. To explore the application of these basic facts of cryogenic gyro design, JPL has run theoretical and experimental studies on the behavior of a superconducting sphere suspended by a magnetic field. Its studies, JPL reports, go far to answer the problems of magnetic field support configuration, operation in vacuum, and readout.

* Jet Propulsion Laboratory, Pasadena, Calif.

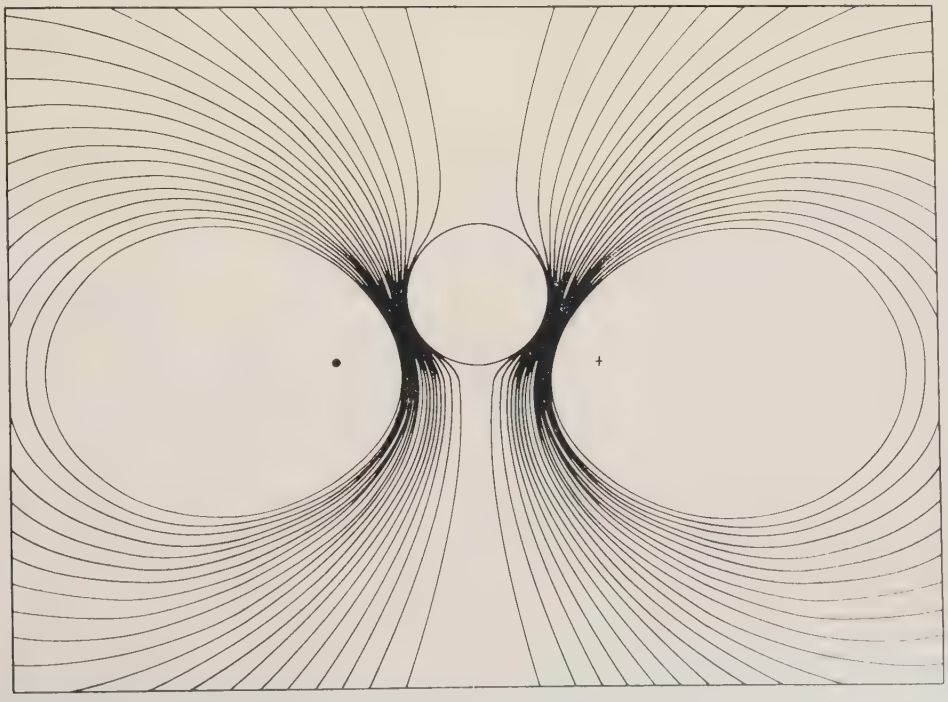
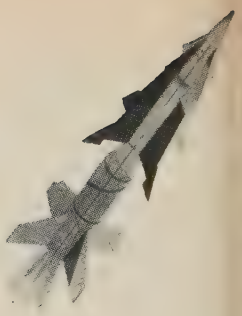


FIGURE 1: Effect of a superconducting sphere on single-coil field distribution.



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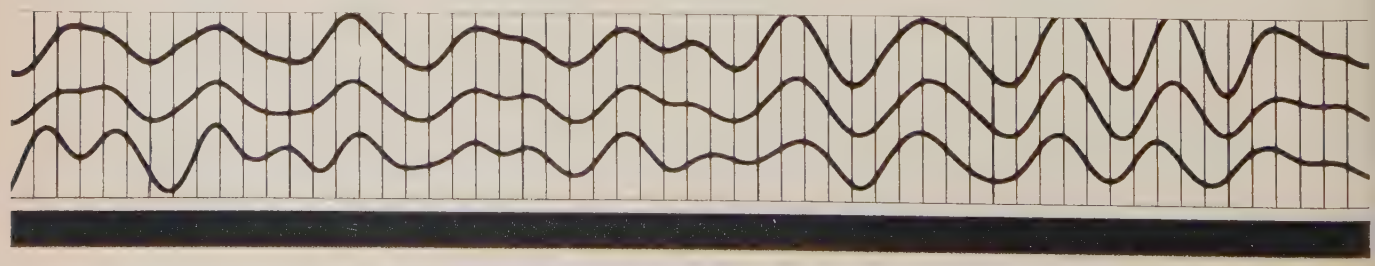

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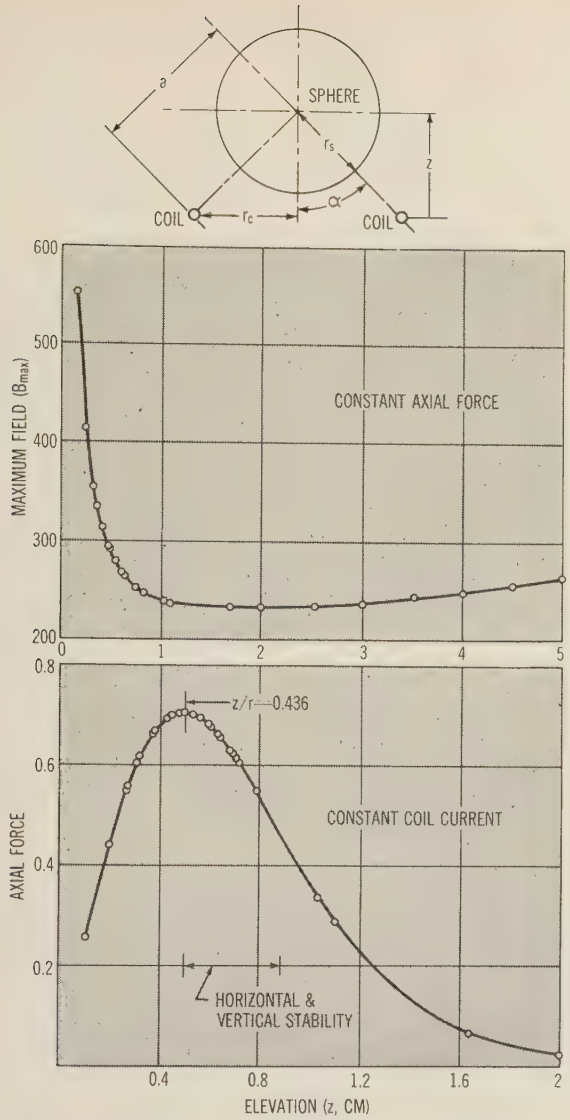

FIGURE 2: Geometry and analysis of single-coil configuration, where r_c is 1.147 cm, r_s, 0.635 m; M, 1.928 gm; and the maximum field and the axial force are in arbitrary units.

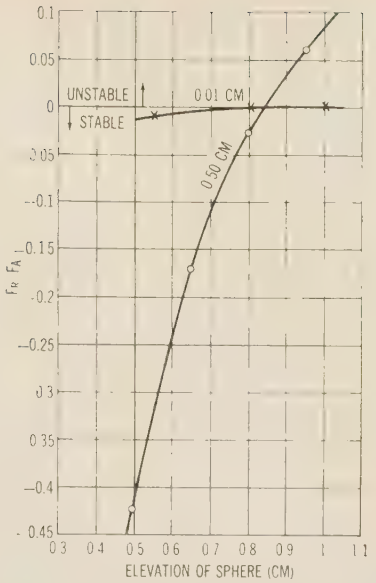

FIGURE 3: Radial stability of an off-axis ball levitated by a single coil for two radial displacements, with $r_c/r_s = 1.8$.

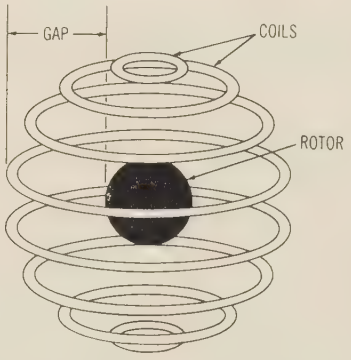

FIGURE 4: Eight-coil configuration. Experiments showed that six coils effectively equal an infinite number of coils.

• Superconductors, being diamagnetic, are repelled rather than attracted by sources of magnetic fields. They therefore provide an inherently stable support, unlike ferromagnetic and electrostatic suspensions which require feedback systems.

• The DC current required for support can be trapped in a superconducting circuit, so that no support power is needed.

• The maximum pressures, as limited by critical or breakdown fields, are higher for magnetic field supports than for electric ones.

• Dimensional instability, a major factor in poor gyro performance, is virtually eliminated if materials are at low temperatures at which their expansion coefficients approach zero.

The principle of the magnetically supported superconductor is based on two properties of superconductors:

• As all resistance to the passage of electricity has disappeared, there is no electric field within a superconductor.

• Magnetic flux is excluded from the interior of a superconductor. This so-called Meissner effect corresponds to complete diamagnetism.

The boundary condition imposed by the Meissner effect is that the component of the magnetic field disappears at the superconducting surface. The magnetic force due to a field B on an element of surface dS is given by:

$$\vec{dF} = (\vec{B}/\mu_0)(\vec{BdS}) - (B^2/2\mu_0)\vec{dS}.$$

The first term on the right disappears for a superconductor, with the result that the magnetic stress, or pressure, is normal to the surface. If the surface is a perfect sphere, all forces pass through the center of mass and no torques are possible, regardless of the ambient, or applied, external fields. Furthermore, the absence of resistivity makes it possible to rotate the sphere without the eddy-current drag of conductors moving through magnetic fields.

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that a hollow lead sphere immersed in liquid helium could be lifted stably by a two-coil support. Culver and Davis, of Rand, in 1956 showed that the cryogenic gyro has great promise as an accurate inertial guidance element. JPL has undertaken an R&D program to transform Simon's basic superconducting suspension into the practical inertial guidance element envisaged by Culver and Davis.

The design of a cryogenic gyro involves six elements: (1) rotor material selection and fabrication, (2) configuration of the supporting field, (3) spin-up, (4) read-out, (5) damping of the rotor vibration, and (6) maintenance at cryogenic temperatures. Our first effort (and the major one to date) has been devoted to an analysis of optimum coil system design. *Figure 1* shows the field plot for the simplest case, a configuration using a coil and a sphere. The field lines do not enter the ball, and there are regions of high field density (where the lines are close together). A very important design characteristic is the minimization of the magnetic fields at the rotor surface—it makes it less likely that a breakdown will be caused by exceeding the critical field strength of the superconductor.[1] We have set up two IBM 704 computer programs to analyze the problem posed by these design characteristics. Fortunately, the case of a perfectly diamagnetic sphere in a magnetic field has particularly simple boundary conditions. For a coaxial array of current-carrying coils and the sphere on axis, the answer can be found in terms of an image solution. The location of the image coil is simply the "inversion" of the real coil with respect to the sphere. The strength of the image coil is greater than the strength of the real coil by the ratio of the distance of the real coil from the center of the sphere to the radius of the sphere.

(1) Superconductivity is destroyed either by raising the temperature above the transition temperature or by subjecting the superconductor to a field greater than a limiting, or critical, field. This critical field is a function of temperature and material.

In our analysis, we emphasized the reduction of the maximum field (B_{max}) on the surface of the sphere for a given lifting force. By varying the values of a and α, we found that the configuration with a ratio of coil radius to sphere radius (r_c/r_s) of 1.8 and a ratio of elevation to coil radius (z/r_c) of 1.4 produces a minimum B_{max} (*Fig. 2*). The transition from axial stability to instability occurs when z/r_c equals 0.436. *Figure 3* shows that the sphere is radially stable for z/r_c-values of 0.435-0.767. We did not study z/r_c-values of less than 0.435.

The rotor also had to be stabilized against high accelerations in all directions. This implied a spherically symmetrical force field.

In designing a symmetrical multi-coil system, the only variable is current density. In addition, a high maximum force was required and the system had to be able to absorb transient acceleration forces. No readout constraints were added (so that there were no gap constraints).

The current density is determined by:

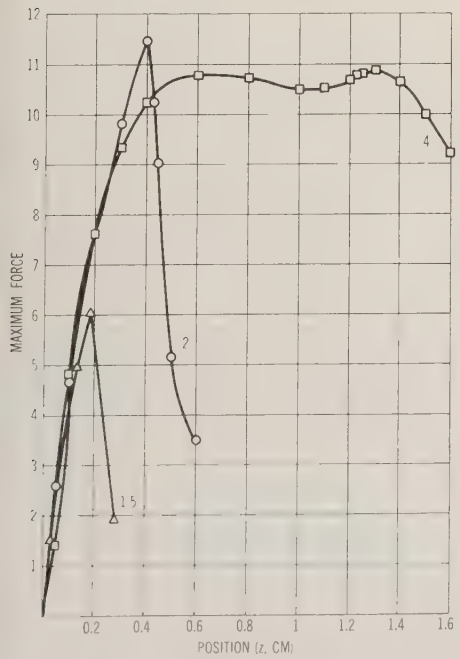
- the direction of current flow;
- coil and sphere geometry (i.e., the distribution of the coils about the sphere and the gap size);
- the relationship of current and coil geometry.

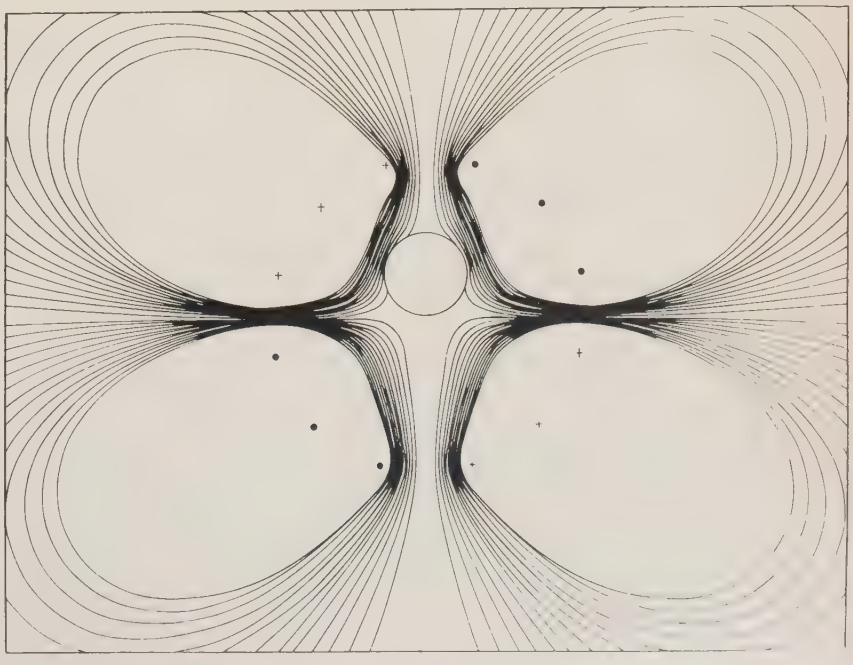
To find the best current direction, we analyzed an eight-coil system (*Fig. 4*) under three conditions:

- current flowing in the same direction in all the coils;
- current flowing in opposite directions in alternate coils;
- current flowing in the same direction in the upper four coils and in the opposite direction in the lower four coils.

The computer program showed that our eight-coil configuration was radially unstable under the first condition, but both axially and radially stable under the

FIGURE 5: Effect of gap size on six-coil configuration (left) for several coil-sphere diameter to rotor diameter ratios (maximum force in arbitrary units). Right: effect of superconducting sphere on six-coil field distribution.





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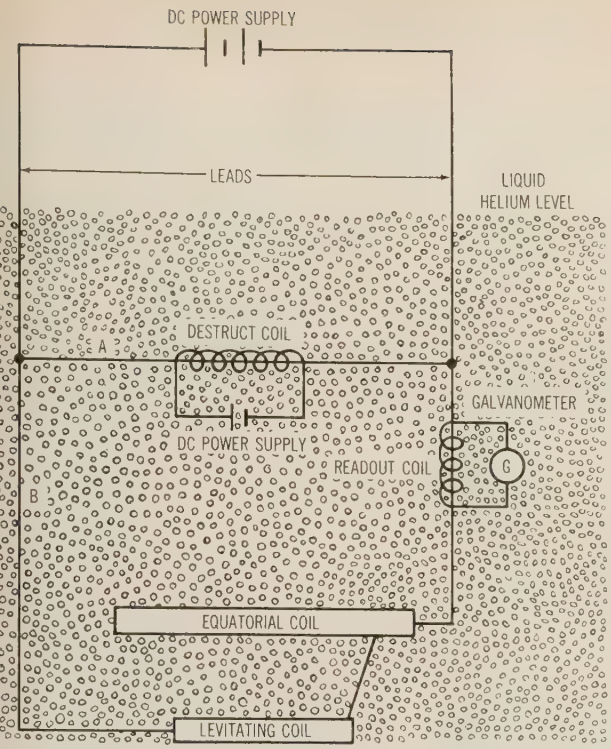

FIGURE 6: Circuit used for trapping current in a superconducting loop has two branches, A and B. When current in the superconducting circuit is destroyed, it induces an instantaneous current in the readout coil that can be read on the galvanometer.

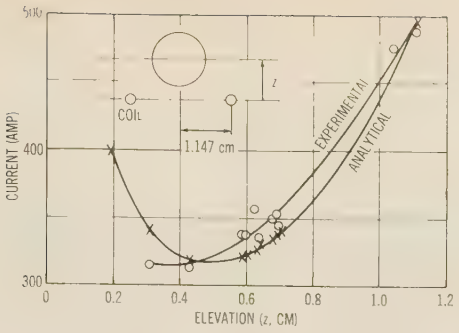

FIGURE 7: Analytical and experimental data for a single-coil-and-sphere (on-axis) configuration. The sphere diameter is 1.270 cm.

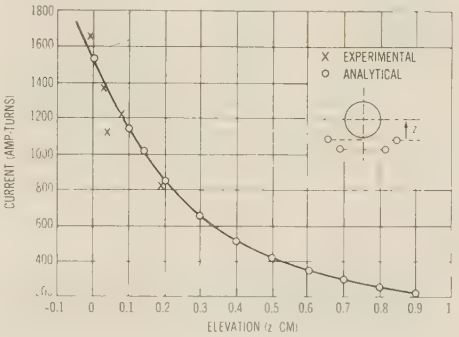

FIGURE 8: Analytical and experimental data for a two-coil (on-axis) configuration.

econd and third conditions. Under the third condition, however, it produced a lower maximum field than under the second.

In evaluating these conditions for maximum force and energy absorption, we used a maximum-force term, computed by increasing the current until the maximum field became equal to the critical field. After varying the number of coils and the coil-sphere diameter (with equal angular spacing and equal current in each coil, we concluded (*Fig. 5*):

- Six coils are effectively equal to an infinite number of coils.
- For maximum force, the optimum ratio of coil-sphere diameter to rotor diameter is 20.

Analyses of the current and coil geometry relationship revealed that, to produce symmetrical stability, the current in the equatorial coils should be greater than the current in the polar coils.

Figure 6 shows the method we devised to trap current into a superconducting loop:

- The DC power supply is set at the required current level. As branch A has less inductance than branch B, almost all the current flows through branch A.
- The destruct coil is supplied with enough current so that its field exceeds the critical field of the superconducting wire that it encloses. This wire then becomes normal, which greatly increases the resistance of branch A. Therefore it is now branch B that carries almost all the current.
- The destruct coil is turned off, allowing branch A to once again become superconducting. The current flowing in branch B then flows through the circuit formed by A and B, since A and B are both superconducting and have infinitely less resistance than the copper leads.
- The DC power supply is turned off, and the current continues to flow through the circuit formed by A and B. This is measured with the readout coil—when it is destroyed, it induces an instantaneous current in the readout coil that can be read on a galvanometer.

To find a method of making superconducting niobium joints, we ran tests that showed that spot-welding of niobium—using high power, low pressure, and short durations (12 millisec for $\frac{1}{32}$-in.-diameter niobium wire)—produced joints that were 85 per cent as good as solid niobium wire and broke down at 85 per cent of the critical field. Tests on superconducting transformers showed that ideal loss-less transformers could be used in high-current applications.

The superconducting rotors for our experiments were made of solid niobium or of lead-plated sapphire, plastic, aluminum, or magnesium spheres. The plating was done either electrochemically or by vacuum deposition. Tests show that these methods can be refined to produce plated material with properties similar to those of the parent material.

For the initial experimental verification of our computer program, we used the optimum single coil and a lead-coated sphere (contained in a glass tube to prevent horizontal displacement). The experimental results agreed with the analytical ones within five per cent in most cases (*Fig. 7*). The maximum variation was 10 per cent.

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JPL's Cryogenic Gyro Research

The purpose of JPL's cryogenic gyro research is to evaluate the known sources of torque. Only if there is a good chance of reducing non-systematic torques below 10^{-2} dyne-cm will a hardware design be started.

The known sources of torque are the non-sphericity of the rotor (including mass imbalance) and the trapped flux in the rotor. In its study of non-sphericity, JPL is running experiments to find out whether the surface acted on by the supporting magnetic field coincides with the measurable geometric surface or whether it does not because of the presence of non-superconducting patches or of regions of non-uniform magnetic penetration. JPL believes it will be particularly interesting to discover whether the torques can be reproduced by temperature cycling. It is also attempting to mass-balance spheres to determine the limits of mass imbalance.

A second set of experiments will be run to evaluate techniques for reducing the trapped flux. Both bulk samples of superconductors (including zone-refined single-crystal rods) and machined and polished spheres will be used. The trapped flux depends on specimen purity, surface preparation, ambient field at the transition to the superconducting state, and temperature distribution in the sample during transition, as well as on whether the superconductor is rotating during the transition.

Results to Date:

- Magnetic levitation of niobium spheres up to 300 gm against one g
- Accurate correlation of experimentally determined support forces with theory
- Levitation of niobium spheres in a vacuum of 10^{-6} mm Hg at an ambient temperature of 4.2 deg K and without loss of support for 24 hours
- Spin-up of rotors to 7000 rpm by helium gas jets during magnetic suspension
- Measurement of the spin-down rate of rotors under 10^{-5} mm hg helium gas pressure —the decay was exponential; for a 6.35-mm-diameter niobium sphere, the speed dropped (because of viscous drag in the helium gas) from 3000 to 2950 rpm in 20 hours

In one of our experiments, a 3.81-cm-diameter lead-coated sphere was stably supported by a single coil. Roughly 1000 ampere-turns were required to levitate the eight-gram sphere. The levitating current was trapped into the superconducting loop and remained constant for about 5½ hours, during which we could observe no measurable change in the elevation of the sphere. This experiment also verified the computer finding that a single coil can provide both horizontal and vertical stability, something that formerly had been considered impossible.

For the experimental verification of both on-axis and off-axis computer programs, we used a solid niobium sphere levitated with an asymmetrical two-coil configuration. The coils were rotated about a radial axis to obtain various off-axis stable positions, and the current was measured and the ball position photographed. In the on-axis comparison, all points except one agreed within five per cent (*Fig. 8*).

As *Figure 9* shows, the off-axis comparison showed differences ranging from 20 to 60 per cent, but these can be attributed almost entirely to measuring error. For example, in the last test, the linear measurement is accurate only to 0.01-0.02 cm. If the horizontal displacement (A) is increased by 0.015 cm, the force ratio (F_r/F_z) becomes 0.48, and the difference in the results is reduced to 17 per cent from 55.

A solid niobium sphere was also levitated in a vacuum. The sphere was inside a tube that could be evacuated and, together with the surrounding two-coil levitating system, was immersed in liquid helium. Radiation shields reduced the heat flow into the tube.

The sphere was first levitated in helium gas at 4.2 deg K, and then the tube was evacuated. A minimum pressure of 2×10^{-6} mm of mercury was obtained during levitation. No heating effects were evident during the levitation period of about two hours.

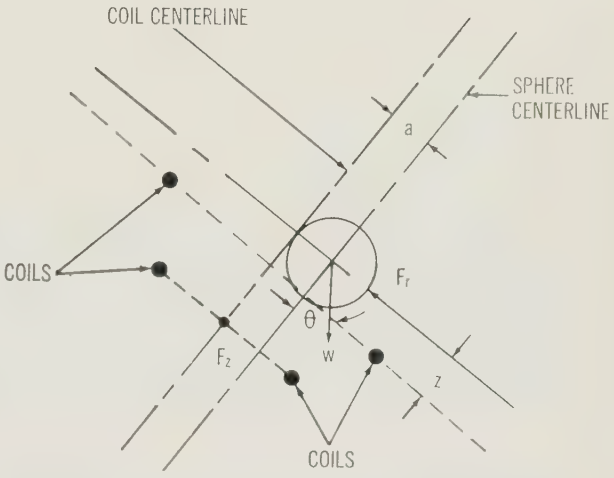

FIGURE 9: Analytical and experimental data for an off-axis two-coil-and-sphere configuration for $\tan\theta = F_r/F_z$ and $F_z^2 + F_r^2 = w^2$.

Experimental Data				Computed F_r/F_z	Difference (per cent)
A (cm)	Z (cm)	θ (deg)	tan θ		
0.03	0.05	10	0.18	0.14	22
0.14	0.11	30	0.58	0.45	22
0.13	0.05	20	0.36	0.58	61
0.11	0.17	20	0.36	0.26	28
0.06	0.02	30	0.58	0.26	55

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Ceramic filters replace IF transformers in command receiver

by R. W. Frykman, Electronics Engineer, G. T. Schjeldahl Co.*

THANKS TO four fixed-tuned, ceramic, emitter-bypass "transfilters," direct-coupled IF amplifiers can be used in a new radio command receiver on our unmanned high-altitude balloons. The new design reduces the volume and weight of the transformer-coupled circuit, simplifies the associated IF circuitry, improves AGC, and maintains amplifier stability and selectivity.

The DC-coupled IF design eliminates transformers between the first and second, and second and third IF amplifier stages and between the last IF and detector stages. This change saved considerable space and volume, even after a third transistor IF amplifier (also DC-coupled) was added to compensate for loss of gain.

* G. T. Schjeldahl Co., Northfield, Minn.

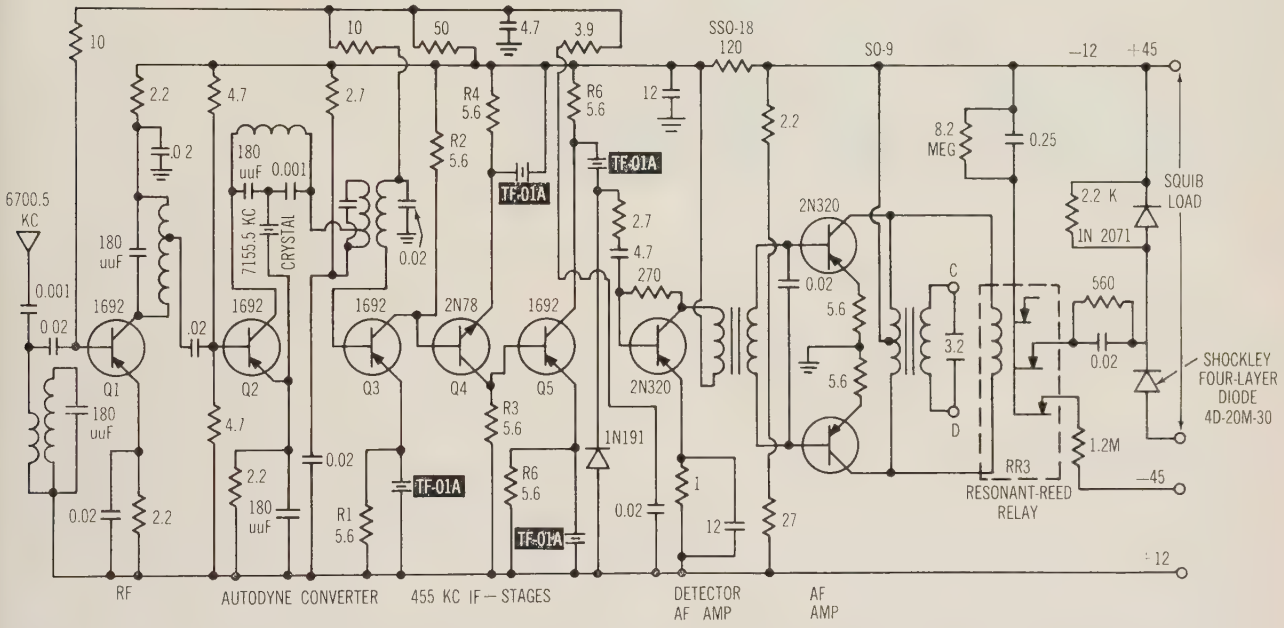

FIGURE 1: Fixed-tuned command receiver uses TF-01A "transfilters" as emitter bypasses in the IF stages and for coupling to the detector stage. (Unless otherwise noted, resistances are in ohms and capacitances in μF.)

IN BRIEF

Three 455-kc ceramic filters are used in place of IF transformers in a fixed-tuned HF command receiver for high-altitude balloons. A fourth is used to couple the IF signal to the detector, or first audio stage. In the IF stages, the filters are connected as emitter bypass elements. They provide a five-kilocycle IF selectivity at the −3-db points and 20 kc at the −60-db points on the receiver's response curve. To provide selectivity, degenerative feedback is produced on both sides of the passband. The advantages of the new design are low weight, simple IF circuitry, improved AGC, environmental ruggedness, and good amplifier stability and selectivity.

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FIGURE 2: Chassis of command receiver for unmanned high altitude balloon.

A second detector triode providing AGC feedback was replaced by a diode. No neutralizing components were required, since the inherent impedance mismatch of the DC-coupled amplifier prevents any effective internal feedback.

The emitter-bypass transfilters provide selectivity by creating degenerative feedback on either side of the 455-kc IF frequency, attenuating undesirable frequencies. The selectivity of the IF amplifier is symmetrical — five kilocycles wide at three decibels down and 20 kc wide at 60 db down. It keeps voice modulation, clutter of skip signals, and heterodynes on the operating frequency from affecting overall receiver performance.

Our radio command receiver is fixed-tuned to 6700.5 kc but can easily be modified to operate on any frequency in the three to 18 mc band.

On its high-altitude (120,000-ft) mission, the receiver must operate at temperatures as low as 32 deg F and at pressures down to 9.52 psi. In the balloon, it receives ground commands, amplifies them, and uses the resulting voltages to trigger special squibs in conjunction with a decoder.

The receiver must be highly sensitive, for it operates over long skip paths. Broad overall selectivity is also necessary to make up for small variations in the carrier frequency of military field communication transmitters.

The airborne unit (*Fig. 1*), is a crystal-controlled superheterodyne receiver that uses germanium transistors in the RF stage (Q_1), the autodyne converter (Q_2), and the IF stages (Q_3, Q_4, Q_5). Audio signals from the receiver are applied to a three-reed resonant relay. When exited by its particular audio frequency, each reed makes intermittent closure with its contact. The relay drives a four-layer Shockley diode to actuate the output relay on or off and energize the balloon equipment.

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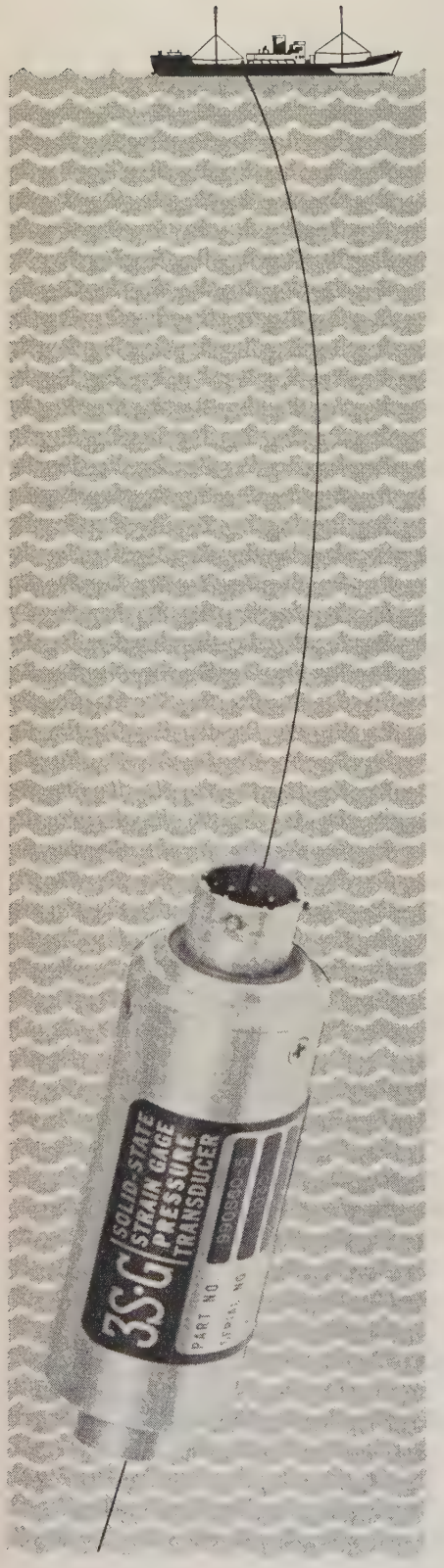
No. 46 on Reader Service Card

LONG LINES NEED STRONG SIGNALS

THE 3S-G SILICON SEMICONDUCTOR STRAIN-GAGE PRESSURE TRANSDUCER

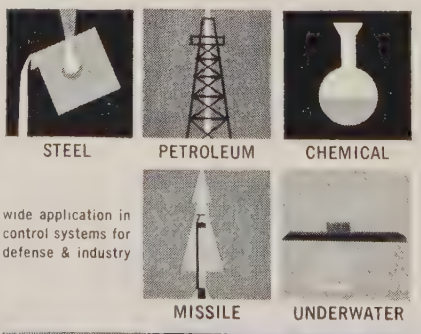


Has a Signal Output of 5 v. d. c.

For remote pressure measurement via long lines—under water or above ground—you need a transducer that delivers a high-output signal without additional amplification. The only answer is the new Fairchild 3S-G. It has a 5 v. d.c. output. And it uses semiconductor materials with piezoresistive characteristics as a sensing element.

Extraordinarily accurate (±.003%/degree F error band is not uncommon) in the roughest environment, the tough 3S-G has infinite resolution, self-contained calibration, temperature compensation, and unexcelled repeatability. It is also available with low output (5mv. to 5 v. d.c.), low-pressure gage and absolute (0-10 to 0-100 p.s.i.), high-pressure gage and absolute (0-100 to 0-10,000 p.s.i.), and high-line low-differential (±10 to ±10,000 p.s.i.d.). All versions operate from −65° to 250°F in practically all gaseous and liquid media, including liquid oxygen, strong alkalies, corrosive acids, and high-energy fuels. All are designed to replace strain-gage pressure transducers now being used by industry and the military.

For more information about the 3S-G silicon-semiconductor strain-gage pressure transducer, write Dept. 51 S/A.



FAIRCHILD CONTROLS CORPORATION

a Subsidiary of Fairchild Camera & Instrument Corporation

225 PARK AVE., HICKSVILLE, L. I., NEW YORK
6111 E. WASHINGTON BLVD., LOS ANGELES, CAL.

ANOTHER FINE PRODUCT OF FAIRCHILD RESEARCH

No. 47 on Reader Service Card

A transfilter is also used as a series-resonant coupler between the IF section and the audio detector-amplifier. The gain provided by the added IF amplifier enabled us to replace the coupling transformer we had previously used.

Direct-coupled amplifiers offer simplicity

Direct-coupled IF amplifiers are fairly independent of variations in transistor properties and supply voltage, therefore they are useful when circuits must be simple, few components are to be used, and stable operation is needed. That they nevertheless have found only limited application in airborne receivers is due to the weight and bulk of the conventional LC components normally required in the emitter-bypass circuits. Transfilters are comparable to these components in providing IF sensitivity and greater environmental stability (*Fig. 2*).

The transfilters used in our receiver are Clevite Electronic TF-01As.[1] Their maximum impedance at the resonant frequency is 16 ohms. The resonant frequency is stable within ±0.1 per cent from −20 to 60 deg C and varies by only 0.1 per cent per decade of time. The IF transformers we had previously used went through a one per cent change in resonant frequency over the same operating temperature range.

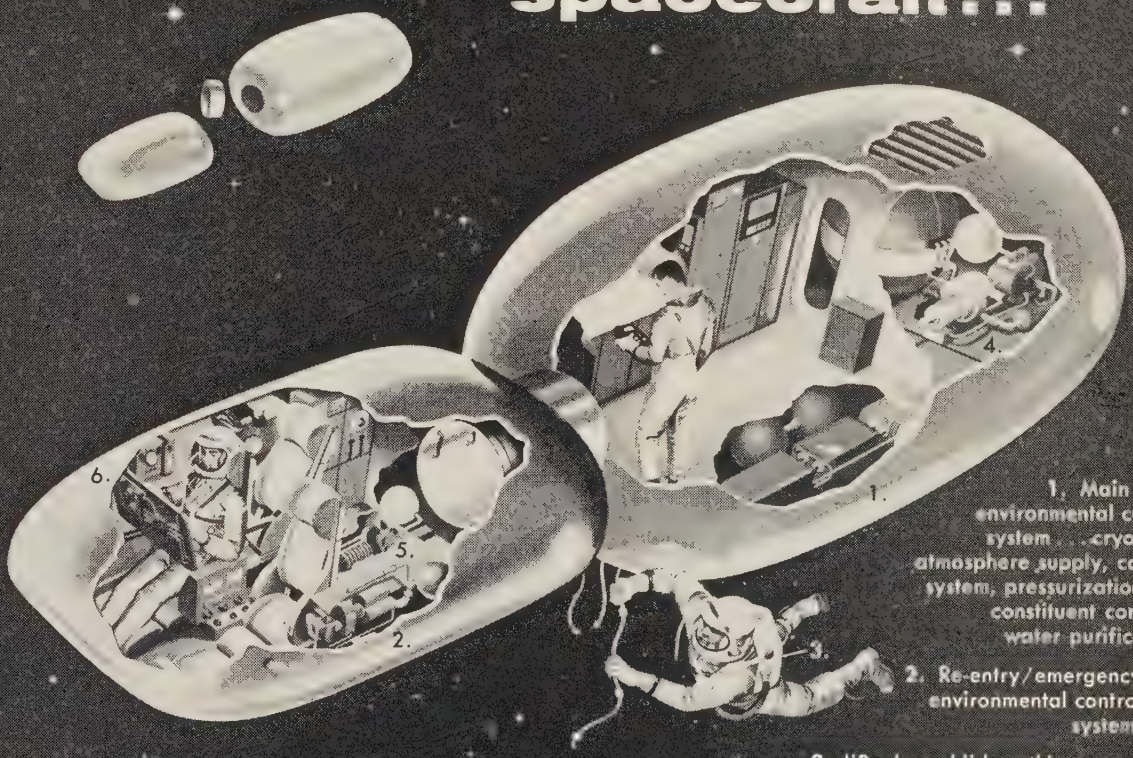
Production and field alignment is quite simple with the DC-coupled design: peaking the coupling transformer between the autodyne converter and the IF stage is all that is required. The AGC improvement is a result of the direct coupling of the IF amplifiers. The feedback voltage applied to the first IF amplifier also controls the second and third IF amplifiers.

In the transformer-coupled design, a second triode detector was required to produce a feedback signal to the first IF stage. This signal had to be strong enough to control the audio signal level. With the AGC advantage gained from DC-coupling, the signal output from a simple diode detector is enough for comparable control. An input signal range of 55 db from five microvolts provides an audio signal level change of three decibels.

For more information, write in Reader Service Card No. 79.

(1) Clevite Electronic Components Div., Clevite Corp., Cleveland 14, Ohio

Environmental and secondary power systems for multiman spacecraft . . .



1. Main cabin environmental control system . . . cryogenic atmosphere supply, cooling system, pressurization and constituent controls, water purification.

2. Re-entry/emergency environmental control system.

3. "Back pack" breathing and pressurization system.

4. Secondary power system . . . multiple re-entry turbine, pump, alternator and cryogenic fuel supplies.

5. Attitude control system . . . reaction motor, fuel and attitude controls.

6. Instrumentation . . . flight data and physiological monitoring systems.

Manned space flight requires reliable and efficient thermal and atmospheric systems and secondary power equipment.

Complete and integrated systems, as pictured, are being studied or under development at The Garrett Corporation. Through optimized design they offer an unmatched degree of compatibility and high performance.

Their design reflects Garrett's 20 years of leadership in developing and producing secondary power and environmental controls for aircraft and spacecraft, including NASA's Project Mercury life support system. This unique capability offers an unequaled source of research, development and production to the government and industry.

THE GARRETT CORPORATION

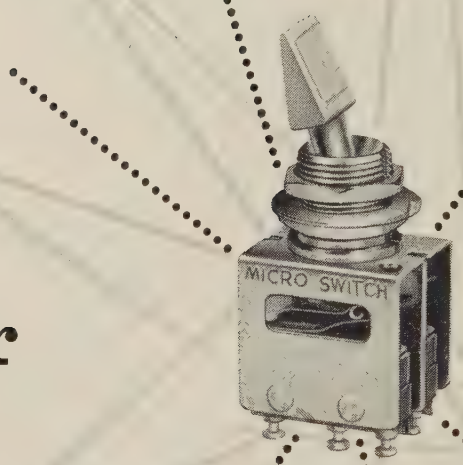
AiResearch Manufacturing Divisions

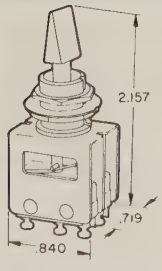
Los Angeles 45, California • Phoenix, Arizona

Systems and Components for: AIRCRAFT, MISSILE, SPACECRAFT, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

No. 48 on Reader Service Card

Versatile Tab-Indicator Toggle Switch





"400" SERIES TOGGLE SWITCHES
Five models available, including 2-position and 3-position types. All are rated at 5 amperes, 250 vac.

The new "400" Series Toggle Switch from MICRO SWITCH has a paddle-shaped tab which can be numbered or color-coded as an indicator. The standard model has a natural metallic finish which will maintain a fresh appearance through long and constant use. The anodized aluminum tab is also available in black or in colors.

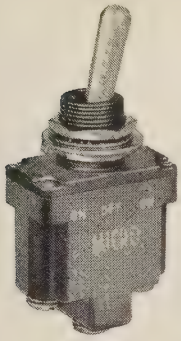
The basic switches used are precision snap-action, long-life units, requiring a minimum of space. They conform to specifications for MIL-S-6743, with two isolated single-pole double-throw circuits. Turret terminals make wiring easy, and contact enclosures are dust-tight.

Five models are presently available in the "400" Series, including both momentary and maintained contact types. Write for Data Sheet No. 174 describing these new tab-indicator toggle switches.

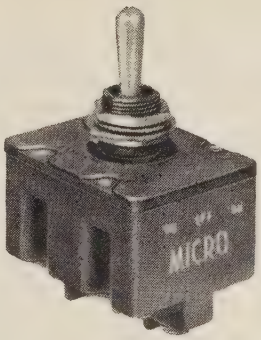
HONEYWELL INTERNATIONAL
Sales and service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

H HONEYWELL

MICRO SWITCH Precision Switches



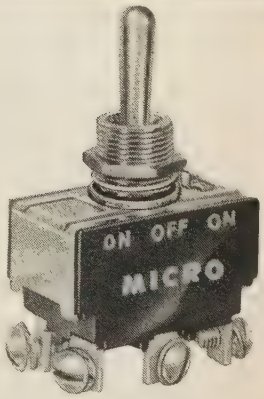
"1TL" Series



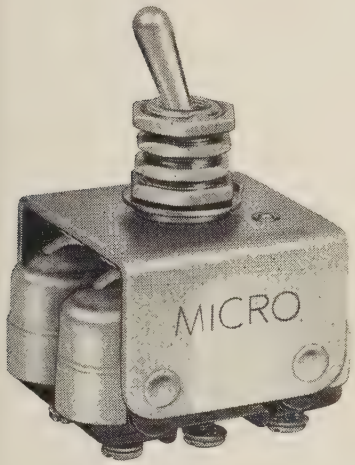
"4TL" Series

"1TL" Pull-to-Unlock

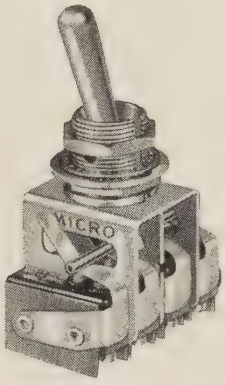
1-Pole "TS"



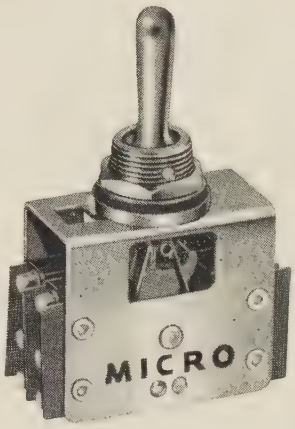
2-Pole
Sealed "TS"



Hermetically Sealed
Assembly



4-Switch Assembly



"Electrical Memory"
Assembly

Subminiature "TM"

Precision Toggle Control Can Be Customized

MICRO SWITCH manufactures hundreds of different toggle switches and toggle switch assemblies. In this complete line you can find the exact characteristics and contact arrangements you need.

"TL" Series Silicone sealer between cover and case seals against dust or moisture. These switches are approved under MIL-S-3950A, operate in a temperature range of —85°F to +250°F. Available in 1, 2 and 4-pole models with integral terminals.

"TS" Series The toggle lever is sealed against dust and moisture. "TS" toggles meet specifications for MIL-S-3950A. Special plastic barrier plus extra distance between terminals. A keyed bushing prevents rotation. Wide choice of contact arrangements includes 1, 2, 3 and 4-pole types.

Subminiature "TM" Weighs only 4½ grams, measures only ½" x ½" at the base. Double-pole double-throw with wide temperature range and low circuit resistance.

"AT" Series Toggle Assemblies MICRO SWITCH offers toggle switch assemblies of up to 16 basic switches. Hermetically sealed types are also available.

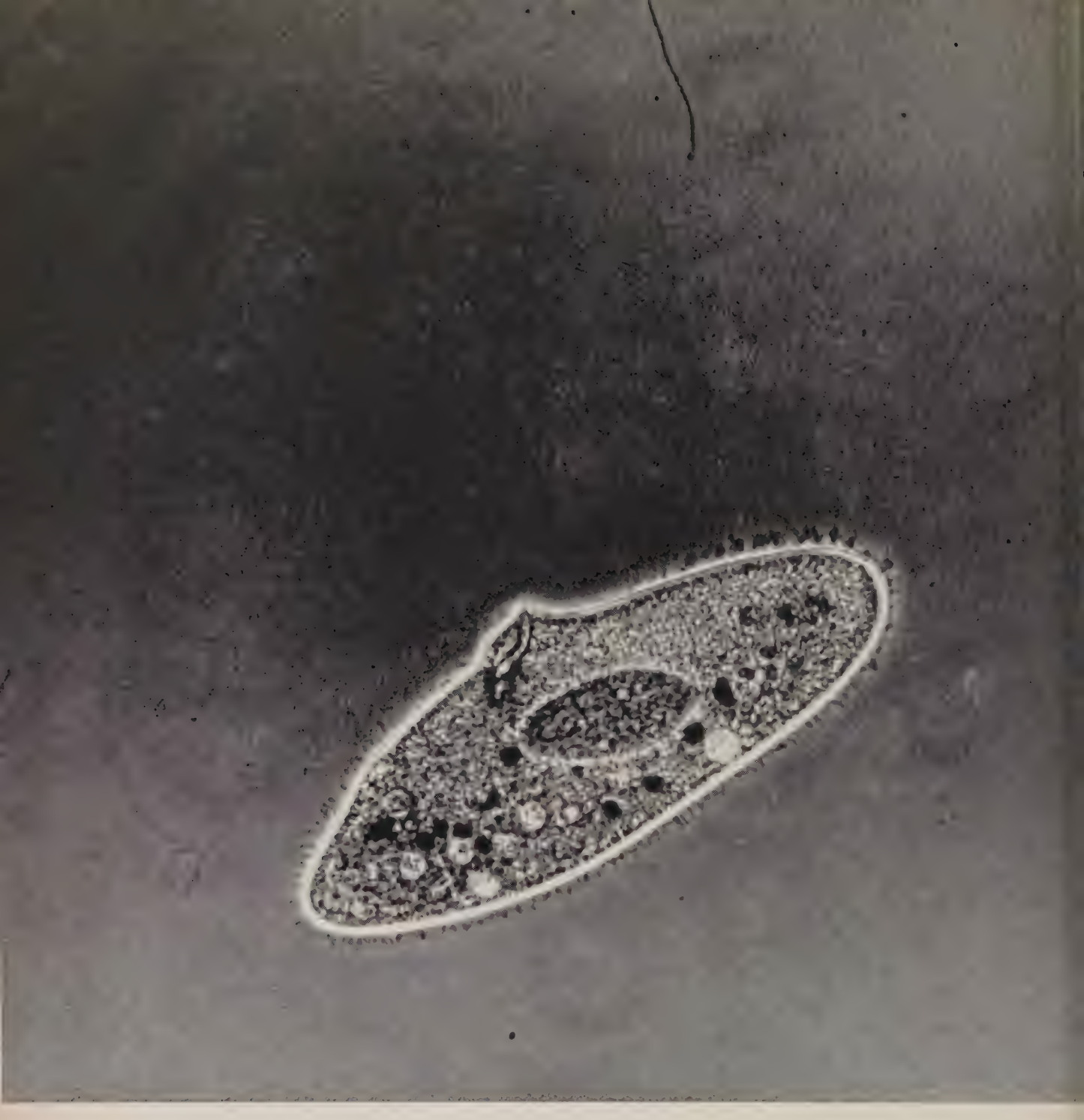
There is a MICRO SWITCH branch office near you and prompt engineering help on the selection of toggle switches is available by simply checking the Yellow Pages. Be sure you get MICRO SWITCH precision and reliability.

WRITE FOR NEWLY REVISED CATALOG 73 ON TOGGLE SWITCHES

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

H HONEYWELL **Honeywell**
MICRO SWITCH Precision Switches

No. 49 on Reader Service Card



We don't want to put life on other planets

Just one living cell. The discovery of just one living cell in space would be one of man's greatest accomplishments. It would affirm the possibility that man-like civilizations could exist on other worlds.

But what if the life we found in space had been put there by our own spacecraft? What a tragic irony that would be!

To prevent this awesome mistake, Cal Tech's Jet Propulsion Laboratory is designing its spacecraft for the National Aeronautics and Space Administration to be 100% sterile before leaving our atmosphere.

The JPL Sterilization Program began even before the first Ranger shot. Different sterilization techniques are being tested in the JPL Lunar Program: heat soaking internal components at 125° Centigrade for 24 hours; coating all exposed surfaces of the spacecraft with ethylene oxide gas; using liquid sterilants during the spacecraft assembly.

By the time Mariner A makes the first "fly-by" to Venus, these techniques will be perfected. Then, spacecraft will be free of any li organism that might upset our hopes of finding other life on other pla

Spacecraft sterilization is only a small part of the work on J Planetary Program and the job of space exploration as a whole. I job that requires the most creative, inventive minds this country ha offer. Minds that will only take know for an answer.

Write to us. Learn first-hand about the fascinating work our scien and engineers do as America's leaders in space exploration. Learn you can be part of this work...how your particular talent will be t to the limit in this, the greatest experiment of mankind.

JET PROPULSION LABORATORY
4816 Oak Grove Drive, Pasadena, California
Operated by California Institute of Technology for the National Aeronautics and Space Administration

All qualified applicants will receive consideration for employment without regard to race, creed or national origin. / U.S. citizenship or current security clearance requi

S/A EMPLOYMENT INQUIRY FORM

August 1961 • Good until October 15 • Confidential • Not an application for employment

THIS INQUIRY FORM is designed to make it easier for you, our engineering reader, to explore employment opportunities in the aerospace industry.
Here is what you do:

- Tear out this page.
- Check off the organization(s) listed below that you would like us to contact. Please use a typewriter or pencil—ink will not reproduce.
- Turn the page over and answer the questions.
- Mail this form in a stamped envelope to:

Engineering Reader-Service Dept.
SPACE/AERONAUTICS
205 E. 42nd Street
New York 17, New York

We will promptly forward a copy of your inquiry form to each of the organizations you specify. If your experience and background matches their requirement, they will get in touch with you at your home.

I am interested in the employment opportunities at:

☐ Aerospace Corp.	10	☐ Lockheed Aircraft Corp.; Georgia Div.	159
☐ AiResearch Mfg. Co.	156	☐ McDonnell Aircraft Corp.	217
☐ Garrett Corp.	156	☐ Mitre Corp.	266
☐ General Dynamics/Astronautics (formerly Convair/Astronautics)	169, 170, 171, 172	☐ Pratt & Whitney	158
☐ General Electric Co.; Def. Syst. Div.	155	☐ Republic Aviation Corp.	157
☐ Jet Propulsion Labs.	152	☐ Space Technology Labs.	30
☐ Johns Hopkins Univ.; Applied Physics	158	☐ United Aircraft Corp.:	
☐ Litton Industries	160	Pratt & Whitney	158
		Research Labs.	156

OTHER: Some of the recruitment advertising in this month's issue of SPACE/AERONAUTICS may have arrived too late for listing. In such cases, just note the name of the organization and page on which the ad appears. Please refer only to this month's ads that direct you to this Inquiry Form.

Name of organization _____ _____

Page on which ad appears _____ _____

NOTE: If you have an immediate interest in any special employment advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

Check Inquiry Form on Page 153

CONFIDENTIAL EMPLOYMENT INQUIRY FORM

Please type or print

FIELDS OF INTEREST—note the general fields in which you would like to work (e.g., basic research, dynamics, structures, propulsion, electronics, testing, production, ground support, etc.):

_____

_____

_____

_____

SPECIALIZED ENGINEERING EXPERIENCE—describe specific technical areas in which you have worked:

_____

_____

_____

_____

_____

_____

EMPLOYMENT—where are you now working and for whom did you work before that?

Employed by 1._____	2._____	3._____
City & State _____	_____	_____
Years_____to_____	_____to_____	_____to_____
Title or Job Function _____	_____	_____
_____	_____	_____

DEGREES—list your college and university degrees:

School _____	_____	_____
City & State_____	_____	_____
Years_____to_____	_____to_____	_____to_____
Degree_____	_____	_____
_____	_____	_____

SPECIAL TRAINING: Briefly describe any special industry, military, or scholastic training:

_____

_____

_____

PERSONAL DATA:

Name _____ Age_____

Home Address_____ Home Phone _____

City & State _____ U. S. Citizen ☐ Yes ☐ No*

* If not, when do you expect to become a citizen? _____

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to SPACE/AERONAUTICS.

Immediate opportunities for graduate engineers and scientists on any of these . . .

4 SYSTEMS ACTIVITIES
you should know more about

Broad generalities are of little help to the professional man who is, after all, only seeking *one* position — hopefully the one which will stimulate him from the start, and continue to provide opportunities for growth through progressively more advanced assignments.

Because the specific program to which you are assigned plays the key role in generating these satisfactions, you may be able to reach some tentative conclusions after reading thumbnail descriptions of four representative programs at General Electric's Defense Systems Department.

The areas described at the right represent only a portion of Defense Systems Department's activities. If your experience is in any of the following areas, we urge you to get in touch with us so that you may get all the facts you need to make the right decision:

APPLIED MATHEMATICS
ASTRONOMY
CELESTIAL MECHANICS
CLASSICAL MATHEMATICS
COMMUNICATIONS
COMPUTERS
COMPUTER APPLICATIONS ENGINEERING
DATA HANDLING
GUIDANCE EQUATIONS
INERTIAL GUIDANCE
INFRA-RED
NUCLEAR PHYSICS
OPERATIONS ANALYSIS
OPTICS
PROPAGATION ENGINEERING
RADAR
RADIATION PHYSICS
STATISTICS
SPACE PHYSICS
SYSTEMS ANALYSIS
SYSTEMS ENGINEERING
SYSTEMS SYNTHESIS
SYSTEMS TEST ENGINEERING
TECHNICAL WRITING
WEAPONS SYSTEMS ANALYSIS

All applicants will be considered for employment without regard to race, creed, color or national origin.

Write in confidence to Mr. P. W. Christos, Div. 60-MI,
DEFENSE SYSTEMS DEPARTMENT,
(A Department of the Defense Electronics Division) General Electric,
Northern Lights Office Building — Syracuse, New York.

GENERAL ELECTRIC

MISTRAM

A revolutionary precision trajectory measurement system now under development. Important future ramifications in extending system to global ranges, satellite tracking, space guidance and hypersonic traffic control. Basic system concept involves geometric arrangement of 5 ground radio receiving stations. Missile position, trajectory and velocities are continuously calculated with great accuracy from phase differences in a beacon signal received from the missile. Radar is used only to orient the radio receiving antennas in the general direction of the missile. Opportunities for EE's in 10 technical areas.

GEESE

General Electric Electronic System Evaluator is a powerful analytical tool. Essentially a hybrid computer system linked to numerous peripheral elements which can selectively simulate an immense variety of electronic signals, scaled to audio frequencies for processing and analysis. EE's with 3-5 years design experience and an analytical turn of mind will find opportunities to work throughout the spectrum of electronics, with GEESE.

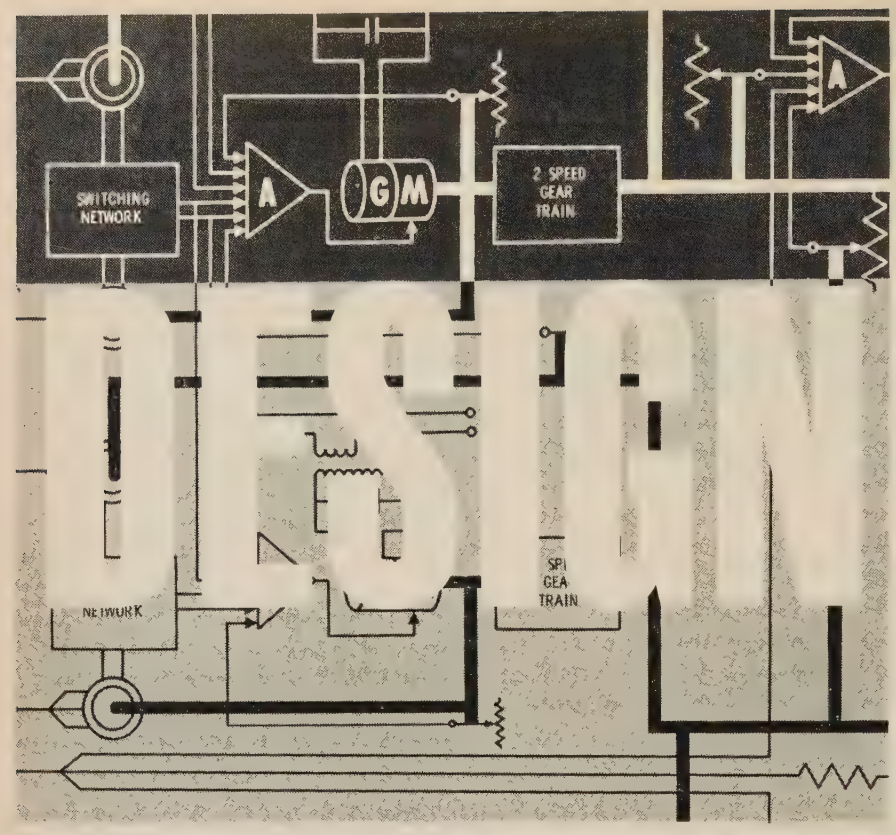
AWCS 412-L

Air Weapons Control System 412-L will consist of a closely coordinated network of data acquisition stations, data processing and display centers and weapon bases. It provides the tools for effective and flexible air space management, continent-wide or in single-point defense. Vital detection and tracking information is supplied automatically to human decision-makers within seconds. Effective direction of both manned and unmanned weapons, including return of manned aircraft to base, is a system function. Numerous openings, ranging from Operations Analysis and Applied Mathematics to Systems and Equipment Design of the many elements involved.

ASTRODYNAMICS

A special group of engineering-oriented mathematicians (and mathematics-oriented engineers) at DSD is exclusively concerned with both theoretical and practical sides of astrodynamics and celestial mechanics. Space probes . . . near-earth satellites . . . lunar satellites and missiles . . . all fall within their range of interests. In addition, the statistical problems of data interpretation and mathematical techniques of vehicle guidance are under investigation.

Check Inquiry Form on Page 153



ENGINEER

An outstanding position is available for a highly creative design engineer who can work effectively with high level analytical and theoretical engineers in the development of complex electromechanical instruments for use in high speed, high altitude aircraft and space applications. At least five years experience and appropriate degree is necessary.

This responsible position requires the personal initiative and ability to render complete and concise layouts for use by designers as well as draftsmen.

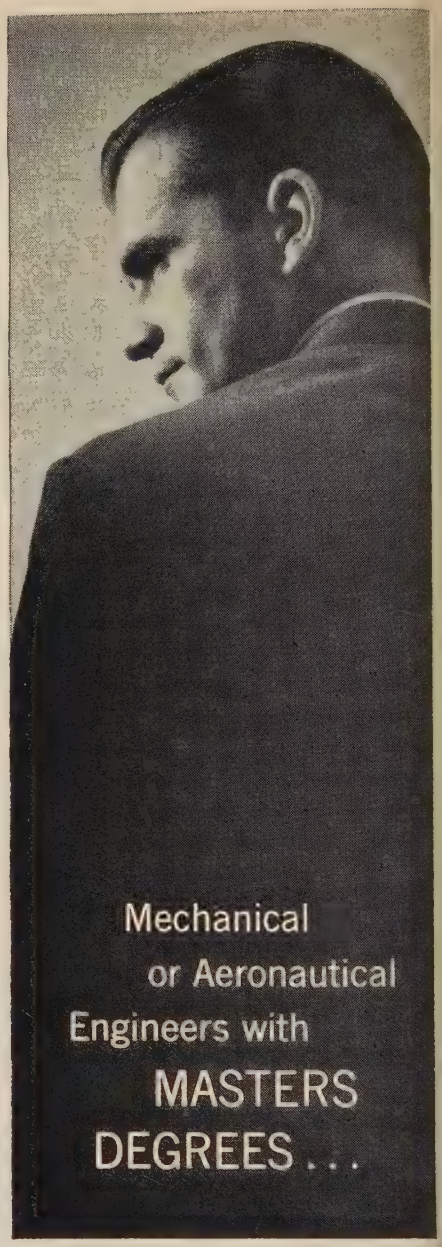
The ability to evaluate equipment and systems specification is essential, and a working knowledge in several of the following areas would be highly advantageous:

pneumatic pressure mechanisms, precision sensing devices such as servoed and nonservoed force balance transducers, kinematics, flexure design, miniaturization, instrument bearing applications, fine pitch, differential and nonlinear gearing applications, anti-backlashing techniques, plate and 3-D cams and temperature compensating devices.

U.S. citizenship or previous security clearance required. Garrett is an "equal opportunity" employer. Send complete resume to Mr. Thomas Watson.

THE GARRETT CORPORATION
AiResearch Manufacturing Division
9851 So. Sepulveda Blvd., Los Angeles 45, California

Check Inquiry Form on Page 153



Mechanical or Aeronautical Engineers with M.S. Degrees and some research or development experience are required for an extensive research program in advanced rocket propulsion concepts. A comprehensive knowledge of fluid mechanics is required (compressible viscous flows, turbulence, transport phenomena) along with the ability to apply this knowledge to unusual fluid flow problems. Both theoretical and experimental programs are being conducted.

This program has strong corporate sponsorship with all that this implies in personal stability. Available are excellent experimental, computational, and library facilities with experienced supporting personnel. Attractive salary levels and benefits are available to qualified individuals.

We invite you to contact Mr. W. I. Walsh

RESEARCH LABORATORIES
UNITED AIRCRAFT CORPORATION
400 Main Street, East Hartford 8, Conn.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Check Inquiry Form on Page 153

ELECTRONIC ENGINEERS & PHYSICISTS

REPUBLIC AVIATION NEWS

NEW RECONNAISSANCE ROLE FOR "ELECTRONIC PLANE"

NEW PRIME CONTRACT AWARDED REPUBLIC CREATES DEMANDING ASSIGNMENTS FOR EE's & PHYSICISTS

The development of a reconnaissance capability for Republic's F-105D marks the first "marriage" of an all-weather reconnaissance system with an all-weather airborne weapon system. The one-man F-105D has already earned the title of the "world's first electronic plane," because its integrated complex of electronic systems permits it to be almost fully automatic. Flight control, navigation, target seeking, identification and tracking, fire control for diverse weapons are all automatically controlled.

With the addition of a sophisticated reconnaissance system the F-105D becomes a flying electronic platform. System design and analysis of the new reconnaissance package and its aerospace ground support present stimulating new challenges to electronic engineers and physicists. Optimum integration of the whole electronic complex offers unique problems.

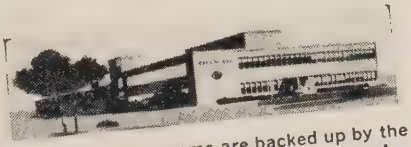
SENIOR & INTERMEDIATE POSITIONS NOW OPEN TO ENGINEERS (EE) AND PHYSICISTS, TO PERFORM SYSTEMS DESIGN, ANALYSIS, TEST AND RELIABILITY ENGINEERING ON:

Radars (front & side looking)
Infrared Systems
Antennas, Radomes
Data Links
Digital Computers
Flight & Fire Control Systems
High Speed Tape Recorders
Optical Systems
Aerospace Ground Support Equipment

These opportunities are at 2 Republic locations: Mineola and Farmingdale, Long Island. For further information, write in confidence to:

▸ Mr. George R. Hickman
Technical Employment Manager,
Dept. 6J
Republic Aviation Corporation
Farmingdale, Long Island, New York

▸ Mr. Paul Hartman
Technical Employment, Dept. 6J-A
Missile Systems Division
Republic Aviation Corporation
223 Jericho Turnpike
Mineola, Long Island, N.Y.



All Republic programs are backed up by the new **Paul Moore Research & Development Center,** an integrated complex of eight laboratories dedicated to the advancement of all aspects of aerospace technology.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

REPUBLIC
AVIATION CORPORATION

Check Inquiry Form on Page 153

engineers • scientists

CHALLENGING CAREER OPPORTUNITIES

in

ADVANCED PROJECTS and APPLIED RESEARCH

The dominant role of Pratt & Whitney Aircraft in the national aerospace program is apparent in the research and development projects and long-range product planning being conducted at their EAST HARTFORD, CONNECTICUT FACILITY.

At present, a limited number of openings exist for specialized engineers and scientists who can contribute to the furthering of technical knowledge within Advanced Research and Development Programs. Experience is required in any of the following fields: liquid rockets, magnetohydrodynamics, nuclear power, thermionic and thermo-electric conversion, hypersonic propulsion, fuel cells and studies in cryogenics.

- Electrical Engineers—for analytical and experimental investigations in advanced rotating machinery of conventional and unconventional design. Investigations in a broad range of new applications including cryogenic and very high temperature high speed machines. Openings for all levels of experience and for degrees ranging from BS to PhD in electrical engineering.
- Aero Thermo Engineers—for performance and optimization studies of all types of advanced power plant and vehicle systems including air and space craft, missile aircraft, marine and industrial applications.
- Applied Science—for advanced research and development work in the fields of nuclear, chemical and direct conversion equipment. Openings exist at BS through PhD levels in Engineering or Physics.
- Nuclear Engineers—to work with advanced concepts in reactor systems and components.

MECHANICAL DESIGN ENGINEERING

Engineers to engage in the mechanical design of propulsion systems, including turbojet, turbofans, liquid rockets, magnetohydrodynamics, nuclear and fuel cell power applications. Must have a minimum of 5 years' related experience.

ANALYTICAL DESIGN ENGINEERING

Engineers with experience in the analysis of propulsion systems design, including the fields of advanced structures, stress analysis, vibration, compressor analysis, turbine analysis and combustion and heat transfer. Must have a minimum of 5 years' related experience.

★

Please submit your resume, including minimum salary requirements, to:

MR. P. R. SMITH, OFFICE 75

All replies will be handled promptly and in complete confidence.

PRATT & WHITNEY AIRCRAFT

DIVISION OF UNITED AIRCRAFT CORPORATION
EAST HARTFORD 8, CONNECTICUT

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Check Inquiry Form on Page 153

ENGINEERS
PHYSICISTS
MATHEMATICIANS

SYSTEMS EVALUATION POLARIS SYSTEM

The Applied Physics Laboratory of The Johns Hopkins University has responsibilities in the evaluation of the Polaris Missile System. We invite you to consider the following career appointments:

Senior Mathematicians

Duties will involve statistical analysis of complex test data for performance, reliability and operation evaluations. A background in physics or electrical engineering is desirable.

Project Engineers

For field test operations involving a team effort of Contractor, Navy and APL Personnel. Work will include launch and flight data acquisition analysis and monitoring of shipboard activities related to the Polaris Missile System. Prefer engineers with considerable background of project level responsibilities.

Systems Engineers

APL has several positions available on the associate and senior levels for men with experience in electrical engineering, physics, mechanical engineering, dynamics, or computer engineering. Will perform systems work related to fire control, navigation, missiles, and submarine controls. Assignment involves field work and contact with the Navy and Contractor Personnel.

Systems Analysts

Respondents must have heavy theoretical background and ability to read and understand telemetry records. Will perform basic analysis of systems related to fire control, navigation, missiles, and submarine controls. May also be required to simulate and solve orbit and doppler equations. Associate and senior level appointments.

Data Requirements, Instrument Engineers

Positions require a physicist or electrical engineer with experience in evaluation, data acquisition and testing of instrumentation installations. Will analyze sub-systems such as guidance, propulsion, controls, boosters, and inertial systems individually and as integral parts of over-all systems to derive data requirements and instrumentation. Duties involve some field work.

APL will provide you with a professional atmosphere conducive to creative effort as well as the tools and technical support required to tackle these and related problems. Our facilities are located in Silver Spring, a residential suburb of Washington, D. C., offering you a choice of country, suburban or city living.

For additional details, direct your inquiry to:
Professional Staff Appointments

The Applied Physics Laboratory
The Johns Hopkins University

8617 Georgia Avenue, Silver Spring, Md.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Check Inquiry Form on Page 153

TRAINLOADS OF TROOPS BY JET: THAT'S AIR-GO*

The greatest future potential is for those aircraft engineers who realize that far more aircraft will be needed to airlift cargo than to carry passengers—and who come now to Lockheed in Georgia where design and production of cargo aircraft are of prime importance.

Here are the finest facilities for production, plus the managerial determination for the continued growth and diversification which make for greater job security and room for personal advancement.

The Atlanta area offers a mild climate, varied recreational and cultural activities, friendly people.

Openings in the fields of: Aircraft Design Engineering Engineering Drawings Checking • Component Design • Aircraft Specifications Engineering Reliability Engineering • Operations Research Aircraft Research Engineering.

Write to: Hugh L. Gordon, Professional Employment Mgr., Lockheed-Georgia Co., 840 W. Peachtree St., Atlanta 8, Georgia.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

***AIR-GO means Lockheed Jetspeed long and short-range airlift delivery systems.**

LOCKHEED-GEORGIA COMPANY

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Check Inquiry Form on Page 153

SUPERVISOR-

ENVIRONMENTAL FACTORS (SPACE SCIENCES)

Starting Salary to $16,500.

A well-known company is expanding its Space Science capability.

Individual selected for position will be expected to direct a group of engineers and scientists engaged in initiating studies relating to space environments, including near-planetary atmospheres, inter-planetary and deep space, to establish effects of such environments on space vehicles and inhabitants, and to establish methods of modifying such effects.

BS Physics or Astro-Physics (advanced degree highly desirable) and 8 to 10 years experience in assignments related to the above. Send detailed resume of experience and salary progression to Box 790, Space/Aeronautics, 205 E. 42 St., New York 17, N. Y. An equal opportunity employer.

Investigating Employment Opportunities?

Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.

Although not an application for employment, it provides employment managers with information to evaluate your capabilities—and in turn gives your request immediate consideration.

Check the "Employment Inquiry" form for details.

INERTIAL SYSTEM INTEGRATION

Can you measure a movement several thousand times slower than the hour hand of your watch? With the skills of an expert organization behind you, could you design and develop your own test methods, equipments, and procedures? These would be for the evaluation of servo, gyro, and accelerometer performance and early prototype inertial systems, and would include precision voltage analog measurements. Write Mr. Donald Krause.

Qualified applicants will be considered regardless of race, creed, color or national origin.

LITTON SYSTEMS, INC. Guidance & Control Systems Div.
Woodland Hills, California

If you live in the EAST or MIDWEST write or phone the LITTON Research & Engineering Staff Representative nearest you:

Mr. Harry Laur,
221 Crescent Street,
Waltham, Mass.
TWinbrook 9-2200.

Mr. Garrett Sanderson,
375 Park Ave.,
New York City, New York.
PLaza 3-6060.

Mr. Robert L. Baker,
360 No. Michigan Ave.,
Chicago, Ill. ANdover 3-3131

Check Inquiry Form on Page 153

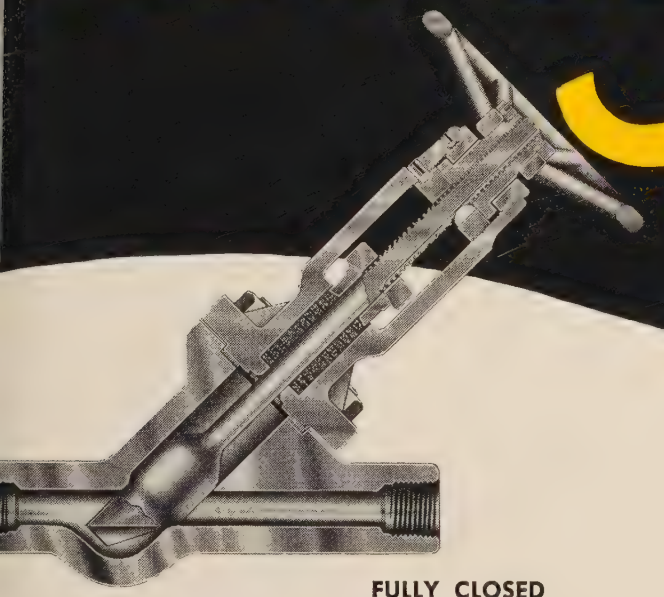
No. 162 on Reader Service Card

a major breakthrough in valve technology . . .

Controls like a globe valve, Flows like a gate valve.

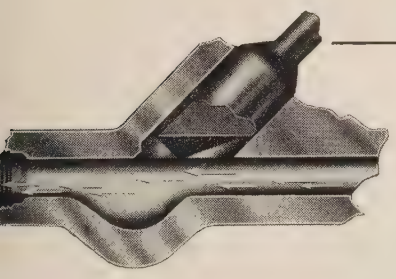
Arrowflo

The ARROWFLO Straight-Flow Control Valve gives performance which is superior to any globe or "Y" valve. The use of this valve will give greatly increased capacity to any existing flow control system as well as giving superior control with less turbulence.



FULLY CLOSED

NON-ROTATING STEM



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The principal advantages are:

- ALMOST ZERO PRESSURE DROP
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CREASES FLOW CAPACITY:

% over standard globe valves, 300% over standard "Y" valves.

Arrowflo Valve gives a full-open and straight-through bore fully opened, yet has positive shoulder shutoff. It is de-d to give outstanding throttling characteristics while having y low pressure drop.

Arrowflo Valve is being widely used in industrial plants, eries, chemical processing plants and missile ground support lations.

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AVAILABLE VARIATIONS:

½" to 12" size,
To 5000 psi working pressure,
Flanged, screwed or welded ends,
Carbon or stainless steels,
Metal-to-metal seat,
Teflon soft seat shutoff,
Extended-bonnet for cryogenic service,
Bellows-sealed for nuclear service,
Quick-opening plug,
Cylinder operator & positioner,
Electric motor actuator.

FLOW SYSTEMS, INC

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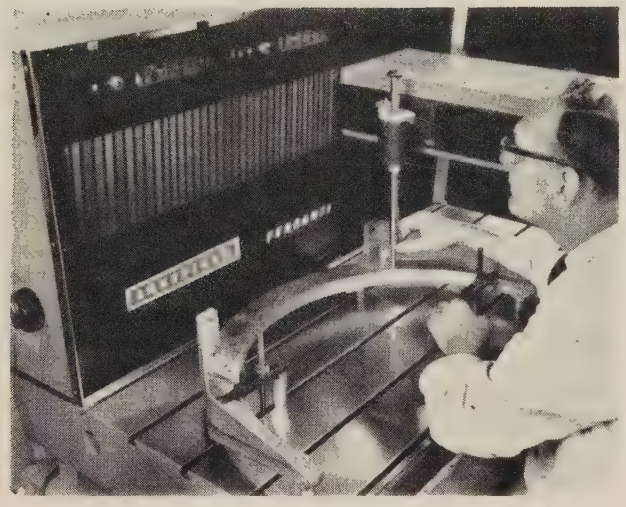
equipment

For details on equipment listed in this section, write in item number on Reader Service Card

COORDINATE MEASURER CUTS INSPECTION TIME

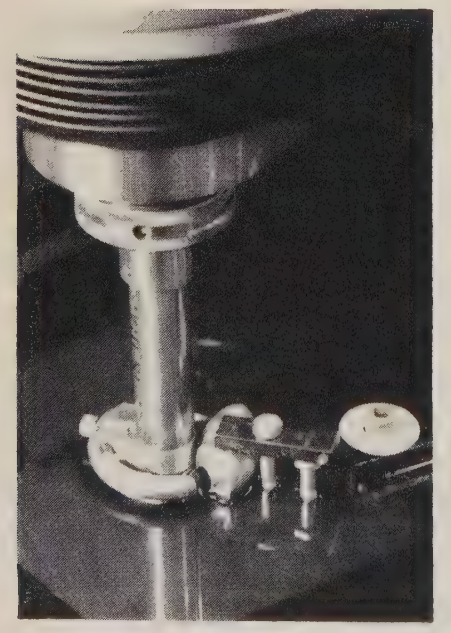


The Ferranti FI-22 coordinate measuring machine, introduced last year by Bendix Corp., is now being sold through The Sheffield Corp., 721 Springfield St., Dayton 1, Ohio. Inspection with the FI-22 is claimed to be up to ten times faster than conventional surface plate and height gage inspection.

The machine measures the distance between holes and surfaces in two dimensions, x and y, to an accuracy of better than 0.001. Both coordinate readings are displayed simultaneously on two illuminated digital readout panels. Floating zeros allow inspection to begin anywhere within the 15×24-in. gaging range.

The Ferranti can also be used as a layout machine by substituting a scribing tip for the probe. By locking one axis, the other axis can be moved to scribe a line. For center-punching, both axes can be locked and a spring-loaded punch tip installed on the probe-holder. The machine sells for $14,300, F.O.B. Dayton. **70**

Electrical-Discharge Disintegrator Can Cut "Around Corners"



A machine that cuts "around corners" yet doesn't touch its work is in everyday use at General Dynamics/Astronautics, P. O. Box 1128, San Diego, Calif. The method was devised to cope with the task of rounding out an elbow pipe with a length-wise oval hole.

Since regular cutting tools can't turn corners, the problem was tackled with an electrical-discharge machine and a new technique was discovered. Experts in the tooling trade agree this is a "first", the company says.

To accomplish the feat, an Elektrojet—the electrical-discharge machine—was used. The machine disintegrates its way through all types of metal, cutting all shapes and sizes. Previously, it had been used for vertical or horizontal work in the tool and die shop.

By means of electrical power, the machine "pecks" away at metal without touching it—a process of electrical disintegration used by the metal-working industry to remove broken taps and produce cavities in hardened metal.

The electricity is carried down an object on the machine that resembles a microscope. At the end of the cylinder an electrode sends thousands of sparks per minute onto the metal. This electrode can be used to burn a square, a hole, or straight line.

In order to correct the oval-shaped interior of the elbow pipe, a brass rod was bent to the proper angle. The rod was attached to the Electrojet and the rod burned its way through and around the corner.

The electrode appears to touch the metal, but doesn't. The tool and workpiece are less than half of one-thousandth of an inch apart, not enough space for a human hair to be inserted.

The electrode can be moved if necessary, but the machine maintains the proper distance mechanically. While being cut, the metal is submerged in oil to wash away debris or dust.

preview

Silicone Rubber Compounds Take Space Environment

The Silicone Products Dept., General Electric Co., Waterford, N.Y., has reported the results of extensive laboratory testing of silicones for missile and space applications. According to GE, the tests indicated that many silicone materials would be operational where other materials could not survive.

The firm showed silicone rubber compounds that had performed for limited periods of time at up to 9,000 deg F. Silicone rubber had previously been considered operational up to approximately 600 deg F.

GE also said that it had silicone "space age" lubricants and hydraulic fluids that, in simulated space environments, had proved superior to the best available materials.

In one test, the silicone materials were compared with synthetic and petroleum lubricants under full evaporative conditions and vacuums down to 10^{-7} mm. The standard GE materials showed a loss of only five per cent, while the other materials suffered losses up to 50 per cent.

GE is also developing silicone lubricants that can withstand full evaporative space conditions. **57**

Sintering Oven Marks Teflon Insulated Wires

The Baltimore Electronics Div., The Martin Co., Baltimore 3, Md., has developed an automatic sintering process, using a specially designed oven, for permanently marking Teflon insulated wires.

The wire is identified with a Teflon foil marking, and the sintering causes a chemical fusion of the Teflon insulation and foil. The resulting identification cannot be removed without destroying the insulation.

The sintering oven uses quartz infra-red tubes to produce radiant heat which is quickly absorbed by the dark marking on the insulation. Oven temperature is controlled by a Variac power transformer connected to a 110 V AC receptacle.

A vari-drive mechanism feeds wire through the oven at a predetermined rate for the particular temperature and wire size. Cooling fans help control sublimation of the heated Teflon. **52**

equipment in brief

ONE-PIECE INSERT is miniaturized

This one-piece insert is designed for areas of reduced edge distance. It is easily installed and locked in the parent material, says **Components Engineering and Mfg. Co., Inc., Dept. S/A, 5468 Valley Blvd., Los Angeles 32, Calif.** An optional thread locking feature is available.

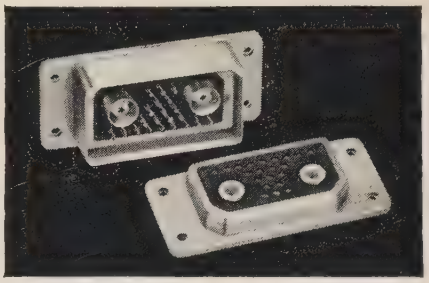
Sizes available are 0-80, 1-64, 1-72, 2-56, 3-48 and 4-40. Materials include steel, stainless steel and brass.

No. 250 on Reader Service Card

HAWK PROVEN CONNECTORS

LIONEL
Series S-20

Extra Reliability With—
- Shell-Enclosed, Die-Cast Housings
- Diallyl Phthalate Moldings
- Positive Alignment & Polarization
- Minimum Depth in Mated Position
- Beryllium Copper Contacts for Extended Insertion/Withdrawal Life



4 sizes: 13 to 41 high voltage contacts, 2 and 4 coaxial contacts; Meet applicable MIL specs; Materials & specifications modified to meet your special needs.

■ *Write Dept. 49-HW for Series S-20 Dimensional Data Sheets*

Lionel Electronic Laboratories
(Formerly Anton Electronic Laboratories)
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Brooklyn 37, N.Y.

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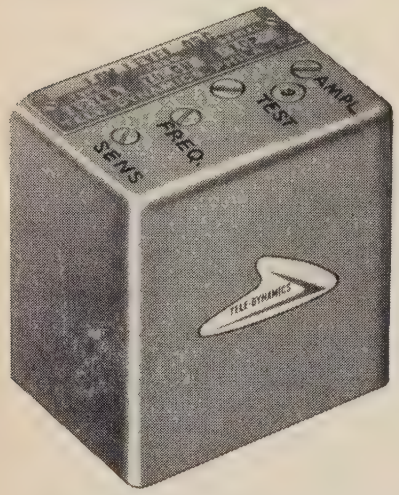
TELEMETRY BY TELE-DYNAMICS

NEW Low Level Subcarrier Oscillator



The Type 1274A Low Level Subcarrier Oscillator is an outstanding member of Tele-Dynamic's new line of transistorized telemetry components for today's aerospace applications.

Designed to operate at unlimited altitudes, the 1274A can be activated by a ± 5 millivolt level differential signal. The input impedance is greater than 90 K ohms. It is extremely stable, has true differential floating input, and inherent deviation limiting which prevents over-deviation of greater than ± 22% from center frequency. Common mode rejection is 110 db min. for a 10 volt peak to peak AC signal up to 2100 cycles. Silicon transistors allow operation over broad temperature ranges and latest packaging techniques reduce the volume of the 1274A to only 4.5 cu. in. and its weight to approximately 4 ounces.

For detailed technical bulletins, call the American Bosch Arma marketing offices in Washington, Dayton or Los Angeles. Or write or call Tele-Dynamics Division, American Bosch Arma Corporation, 5000 Parkside Avenue, Philadelphia 31, Pa. Telephone: TRinity 8-3000.

8410

TELE-DYNAMICS
DIVISION
AMERICAN BOSCH ARMA CORPORATION
5000 Parkside Ave., Philadelphia 31, Pa.

GLASS EPOXY LAMINATE *is flame retardant*

This glass fabric epoxy laminate is flame retardant, solvent resistant, and excellent for cold-punching. A principal application is as printed circuit boards in ground and airborne computers, according to **Continental-Diamond Fibre Corp., Dept. S/A, Newark, Del.**

Called Di-Clad 614, fabricated parts formed from the product are said to show that "haloing" and edge-lifting are virtually eliminated. The grade can be fabricated satisfactorily at normal room temperatures.

No. 261 on Reader Service Card

HAND TOOLS *for microminiature uses*

A line of precision tools of active elements from 0.001 to 0.01 in size has been developed by **Circon Component Corp., Dept. S/A, Santa Barbara Municipal Airport, Goleta, Calif.** The line includes sixty-seven different "microtools," all of which are completely interchangeable in handles provided, says the manufacturer.

The entire tip area behind the working element is 24-carat gold plated and shot-burnished to insure corrosion resistance and a contaminant-free tool. Clean design of handle and tools is said to make them ideal for white room usage.

No. 262 on Reader Service Card

CERAMIC ADHESIVE *for high temperatures*

A ceramic adhesive, called Melbond CA-100, possessing a maximum service temperature of 2600 deg F after being cured at 250 deg F, has been announced by **Melpar, Inc., Dept. S/A, Falls Church, Va.** It is said to have excellent electrical properties.

The adhesive has a paste-like consistency and is applicable for coating items requiring high-temperature protection.

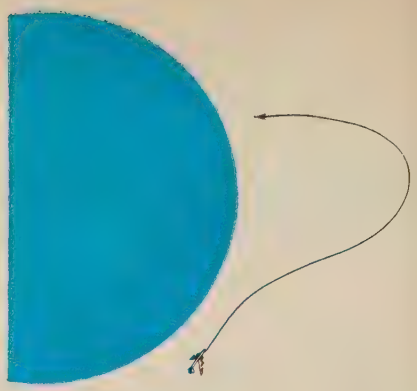
No. 263 on Reader Service Card

MOLDED PLASTIC *for rocket tubes*

A technique for molded plastic rocket motor exhaust tubes has been announced by the **Fiberite Corp., Dept. S/A, Winona, Minn.** The technique utilizes two fiberite formulations—compound MX2625 for mechanical strength, and MX2630-A-67 for ablation resistance.

Molding these two formulations into a composite structure, it is said, combines the needed features of both.

No. 264 on Reader Service Card



SKYBOLT

This new USAF weapon now under development will combine the range and mobility of the jet bomber with the speed and the difficult-to-detect capabilities of the ballistic missile. Yet Skybolt's warhead-carrying re-entry vehicle must operate with the same reliability and accuracy of ground-launched re-entry vehicles.

Environmental conditions—The re-entry vehicle must withstand hour after hour of vibration and noise fatigue aboard its bomber "launching pad"—the USAF B-52 and the RAF Vulcan bomber. Its heat protection system must endure repeated thermal cycling from ground take-off temperature to −65° F at cruising altitudes. If launched, it could be exposed to re-entry temperatures of 7500° F.

Extended Life—Skybolt's re-entry vehicle must have a useful life of several years, through repeated storage, thermal cycling, and return to storage—all with a minimum amount of maintenance.

The Skybolt missile system is being developed from known and proven engineering principles, resulting in rapid program advancement at great saving to the American taxpayer. The Missile and Space Vehicle Department of General Electric's Defense Electronics Division is developing Skybolt's re-entry vehicle. 160-05

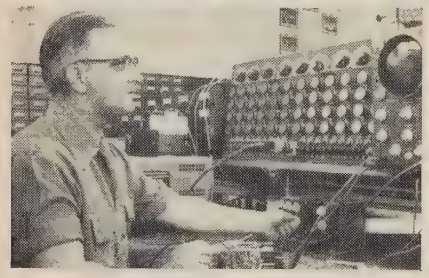
GENERAL ELECTRIC

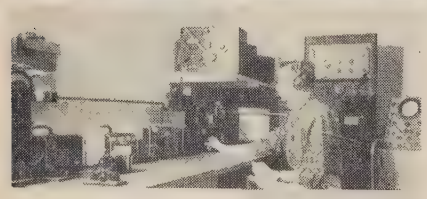
SSILE AND SPACE VEHICLE DEPARTMENT, PHILADELPHIA, PA.

SKYBOLT is being developed to add a new dimension to America's growing missile might. Launched from an airborne B-52, it is being designed to arc through space toward targets more than 1000 miles away. The re-entry vehicles for this advanced USAF missile are being developed by General Electric's Missile and Space Vehicle Department under contract to Douglas Aircraft Company, prime contractor for Skybolt.

GENERAL ELECTRIC

"Testing" with 7,000 sq ft of facilities at Barber-Colman





...important part in the Barber-Colman concept of "total engineering for maximum practicality and reliability."

THE MARK OF QUALITY

BARBER COLMAN

From basic idea creation to the finished product . . . *all* aspects of the customer's problem are given complete attention at Barber-Colman. Testing operations, such as pictured here, join development . . . design . . . application . . . and production engineering in the hands of highly experienced men who know what to look for — and how to achieve it — for highly practical, reliable design. For information on how you may put this kind of engineering to work on your aircraft or missile accessories and subsystems (electromechanical actuators, air valves, temperature controls, positioning systems), consult the Barber-Colman engineering sales office nearest you: Baltimore, Boston, Dayton, Fort Worth, Los Angeles, Montreal, New York, Rockford, San Diego, Seattle, Winter Park, Florida.

BARBER-COLMAN COMPANY
Aircraft and Missile Products Division
Dept. U, 1423 Rock St., Rockford, Illinois
No. 82 on Reader Service Card

BORON COATING prevents blast damage

Boron flame-proofing chemicals applied to a large rocket engine protected a second stage thrust chamber skirt from rocket-blast damage, according to **Dyna-Therm Chemical Corp., Dept. S/A, Culver City, Calif.** The flame-resistant coating, amounting to a fraction of an inch in thickness, it was said was applied to the trailing edge of the thrust chamber's ablative skirt on a firing test.

The coating is a phosphate and boron chemical dispersion in a polyurethane binder. It is applied in the field by brush or spray methods. Under heat, the coating becomes intumescent, forming a surface which protects underlying materials.

No. 265 on Reader Service Card

MACHINE for shear forming

This horizontal shear forming machine will handle both cylindrical and conic parts up to 70 in. in diameter. It is intended for the production of large-diameter rocket cases, according to the **Floturn Div., Lodge & Shipley, Dept. S/A, 3055 Colerain Ave., Cincinnati 25, Ohio.** These ultra-high-strength steel cases are presently formed by machining operations in which the wall thickness of cylindrical forgings is machined to tolerances measured to three decimal places.

The combined weight of the machine is 190,000 lb. It is powered by a 150-hp drive motor, with an additional 48 hp requird to operate the compact hydraulic system.

No. 266 on Reader Service Card

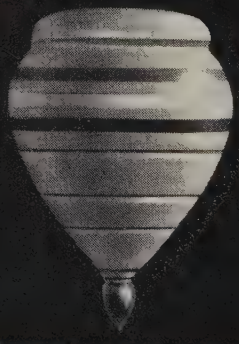
INERT-GAS WELDER is combination AC/DC

This is an all-purpose AC/DC, inert-gas-shielded-arc welding machine. It is available in two models, ADI-2641 rated at 200 amp, and ADI-3641, at 300 amp, says **Hobart Brothers Co., Dept. S/A, Troy, Ohio.** By changing a switch, or by the use of simple plug-in controls and accessories, the units can be used for manual, automatic, tungsten inert-gas inert-gas spot or gas-shielded-arc consumable electrode welding.

The machines are designed for operation from single-phase 230/460 AC power. Welding cables for both "TIG" and metal arc welding remain permanently connected. The operator switches to either welding method.

No. 267 on Reader Service Card

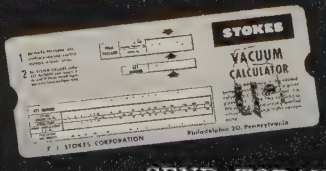
a vacuum pump as dynamically balanced as . . .



Engineered to give you years of vibration-free, superior operation, Stokes Series H Microvac pumps are the most advanced in their class. Exceptionally compact, Stokes pumps take up 50% less floor space than conventional vacuum pumps.

Learn all the reasons why Stokes offers you more pumping performance per dollar. Simply write: Vacuum Equipment Division, F. J. STOKES CORPORATION, 5500 TABOR ROAD, PHILA. 20, PA.

STOKES



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Vacuum Slide Calculator!

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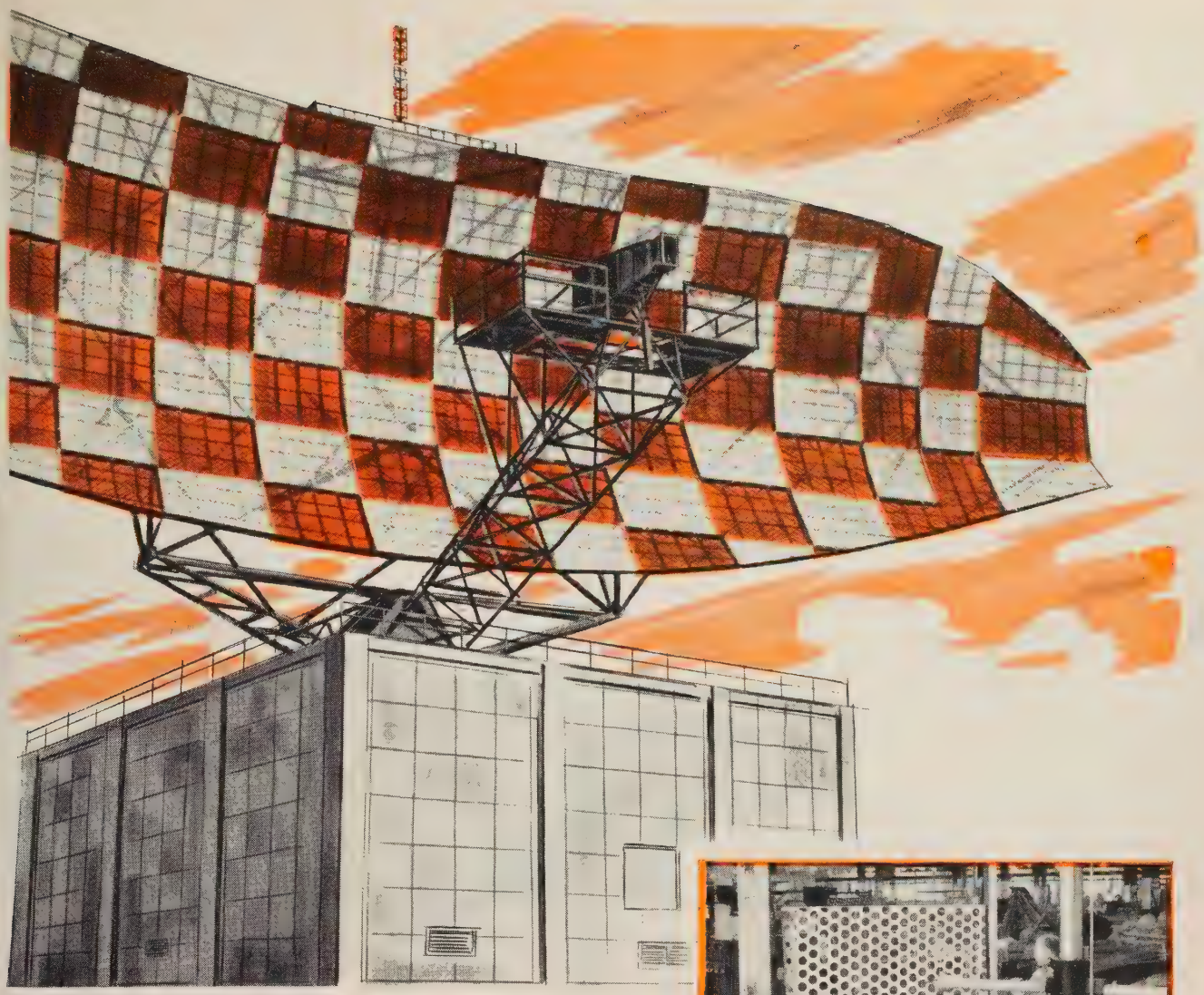
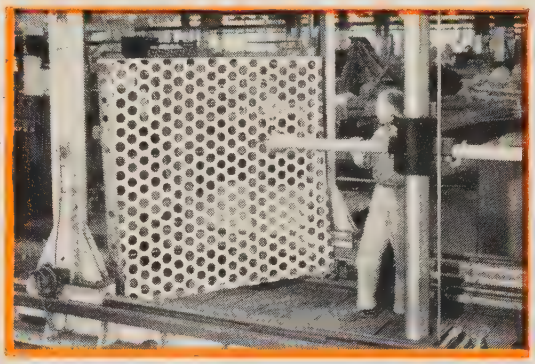


Sperry FPS-35 radar with antenna fabricated by B-L-H.

B-L-H fabricates giant USAF radar watchdogs



Portage machine, one of largest ever built, checks curvature of radar antenna panels, gives micrometerlike direct reading to within .010 in.

Eight huge steel antennas—each weighing nearly 70 tons, 38 ft. tall at midpoint, 125 ft. from blunted tip to tip—had to be fabricated. Sperry Gyroscope picked B-L-H. These antennas are the transmitting and sensing elements of the Sperry FPS-35 radars now being installed for the nation's new Air-Search Radar network.

Each antenna is faced with 101 panel sections, which consist of steel sheets perforated with 3-in. holes on 4-in. centers. Panels had to be fabricated with extreme care because construction to precise yet varying curvatures and sizes is vital in preventing cumulative tolerance errors that would seriously weaken the radar's capability. Some 50 different panel sections had to be made.

Most of the strength of the antennas, which must withstand 126 mph winds, is supplied by a network of supporting trusses. Fifty-two sizes of seamless steel tubing were used in constructing this pipework. And in fabricating the base structure, a steel ring of 149½-in. diam. had to be turned to a flatness tolerance of .003-.004 inch in 360 degrees.

Because of its broad experience, its enormous shop areas, and its unsurpassed facilities for the fabrication of large, unwieldy structures, B-L-H is able to carry out projects of this magnitude efficiently and economically. It will pay you to consult us. Write Dept. R-9 for further information and for illustrated literature.

BALDWIN · LIMA · HAMILTON

Industrial Equipment Division · Philadelphia 42, Pa.

No. 84 on Reader Service Card

Taber Transducer logs 1,500,000 cycles in Pall filter tests without repair

The sensitivity, continuous performance and economical life of Taber bonded strain gage pressure transducers are proved in test operations at Aircraft Porous Media, Inc., a subsidiary of Pall Corporation, Glen Cove, N. Y.

This leading manufacturer of porous stainless filters uses Model 176 Taber Teledyne Pressure Transducers in fatigue testing pneumatic and hydraulic filter units for missiles, aircraft, and atomic submarines. During these tests, pressure pulses from zero to 10,000 psi are sensed and recorded on an oscilloscope at a rate in excess of 150 cycles per minute. Rate of pressure rise is in the range of 200,000 to 300,000 psi per second. The unit shown above has been in operation in excess of 1½ million cycles *without repair or overhaul.*

For full information on Taber Transducers (in pressure ranges from 0-50 to 0-10,000 psi) for test, ground support, and airborne applications, send this coupon attached to your letterhead.

TO: TABER INSTRUMENT CORPORATION
AEROSPACE ELECTRONICS DIVISION SECTION 36
107 Goundry Street, North Tonawanda, N. Y.
Send detailed information on Taber Teledyne and Teleflight bonded strain gage pressure transducers.

name _____ title _____

company _____ dept. _____

address _____

city _____ zone _____ state _____

No. 85 on Reader Service Card

FLEXIBLE TUBING is lightweight

A type of flexible tubing that weighs "less than half the weight of other fabric-covered ducts" has been announced by **Flexible Tubing Corp., Dept. S/A, Guilford 2, Conn.** It has been developed for air conditioning and heating ductwork in aircraft.

Having a temperature range of —40 to 200 deg F, the tubing may be used for either hot or cold air. It is said to be crushproof and can withstand as much as 100 per cent deformation without harm.

No. 268 on Reader Service Card

VAPOR DEGREASER cleans production parts

This air-cooled vapor degreaser is electrically heated by 115 volt ac power. According to **Beta Engineering Co., Dept. S/A, 2924 Quenby Rd., Houston 5, Tex.,** dirty parts can be cleaned and dried in minutes in this 25 lb degreaser.

Trichlorethylene solvent is used and kept clean by vaporizing and condensing processes. On special request, the company can set the unit to use Freon "BF" or "TF" solvents.

No. 269 on Reader Service Card

STAINLESS STEEL for free machining

A free-machining chromium-nickel stainless steel, designated Uniloy 303MA, has been developed by **Universal-Cyclops Steel Corp., Dept. S/A, Bridgeville, Pa.** It is said to permit increased output of machined parts.

Corrosion resistance of the steel is said to be much greater than that of Type 303 and it provides "superior" surface finish.

No. 270 on Reader Service Card

EPOXY ADHESIVE sets in 45 seconds

An epoxy adhesive, X-305, sets in 45 sec with a single drop of activator to two drops of the base material. The mixing ratio of base adhesive to activator is measured either by weight or volume, says **Mereco Products Div., Metachem Resins Corp., Dept. S/A, 530 Wellington Ave., Cranston 10, R. I.** Bond strength is placed at 2000 psi.

The adhesive is offered in two physical forms, as a syrup and as a petrolatum-like jelly. Both forms are available clear or colored and metallic pigments.

No. 271 on Reader Service Card

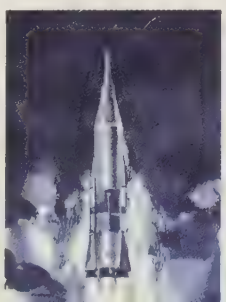
Check Inquiry Form on Page 153

If you are a hardware-oriented engineer who enjoys the shirt-sleeved atmosphere of field assignments, General Dynamics | Astronautics has a number of important assignments in the activation of Atlas ICBM bases throughout the United States. The basic task is providing a wide range of technical assistance to the Air Force in bringing bases to operational capability.

Base Activation Engineers function at the systems level in the installation, checkout, and acceptance of ground support and missile-borne equipment. Specific requirements and locations of work are detailed on the back of this page.

These positions provide stability, growth opportunity, and the satisfaction of working on a program which is not only technically advanced, but of vital significance to the security of the free world.

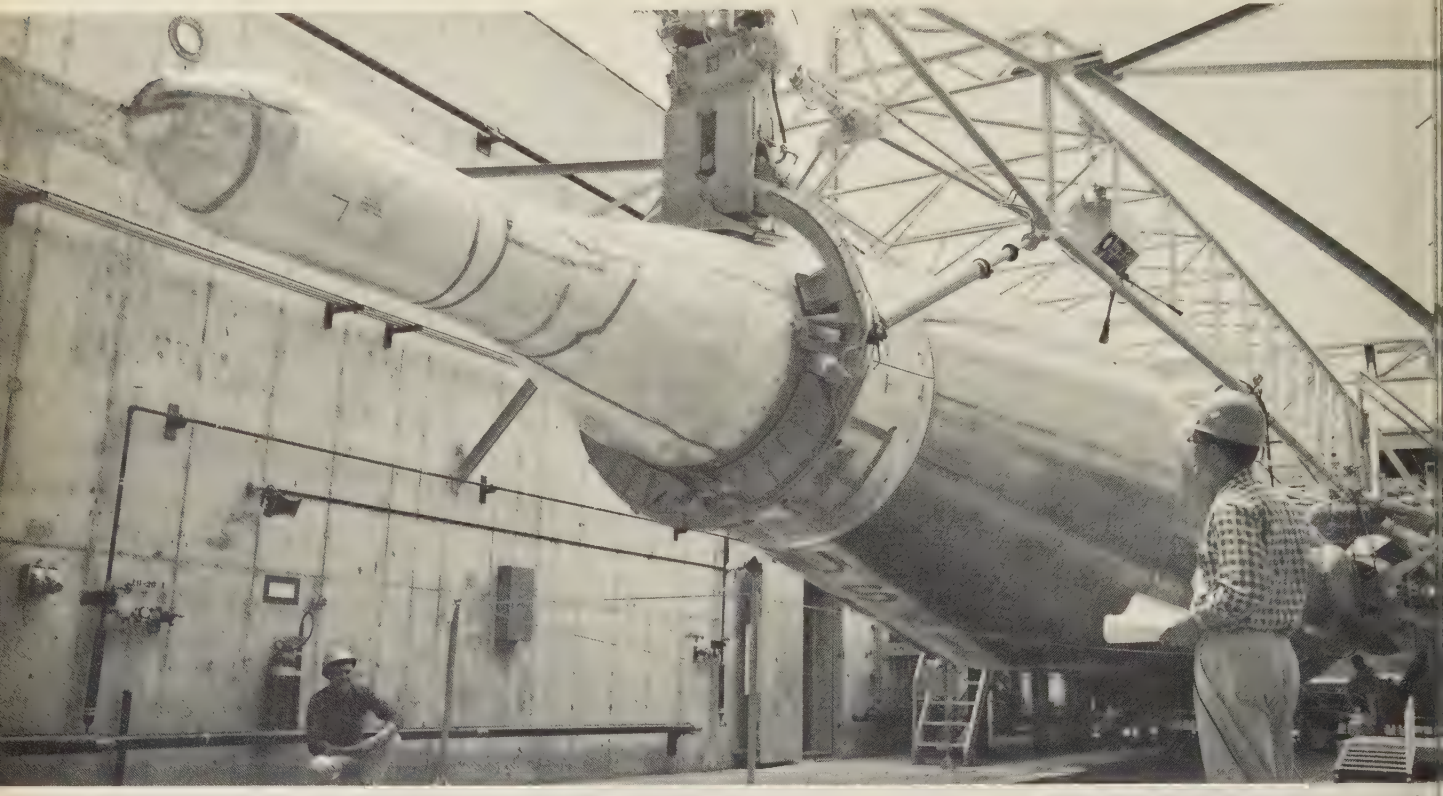
For a prompt, confidential reply, use the attached Professional Placement Inquiry card or write to Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Department 130-90, General Dynamics | Astronautics 5691 Kearny Villa Road, San Diego 12, California. Candidates who live in the New York area may find it more convenient to contact Mr. T. W. Cozine, General Dynamics | Astronautics, 1 Rockefeller Plaza, New York, telephone, CIrcle 5-5034.



GENERAL DYNAMICS ASTRONAUTICS GUIDED

FORMERLY CONVAIR | ASTRONAUTICS

ENGINEERS FOR BASE ACTIVATION



ATLAS MISSILE shown in horizontal launcher at operational base. Current assignments for base activation engineers are at Altu Oklahoma; Abilene, Texas; Roswell, New Mexico; Plattsburgh, New York.

DESIGN/LIAISON ENGINEERS

Tasks involve liaison and design support work in connection with launch control equipment, propulsion systems, automatic programming and missile checkout equipment. A degree in mechanical or electrical engineering and systems experience desired.

ENGINEERING WRITERS

To prepare maintenance, operation, and inspection manuals, and engineering proposals. At least two years of college engineering and 1-3 years of experience in this field desired.

FIELD SERVICE ENGINEERS

Assignments are for specialists capable of representing the company to the Air Force in technical aspects of the Atlas ICBM. An engineering degree and field experience desired.

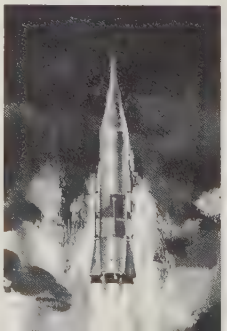
ELECTRICAL/ELECTRONIC ENGINEERS

Graduate engineers with field experience in launch controls, logic control systems, automatic checkout equipment, guidance and flight control, facility electrical power, electronic systems, R.F. systems, telemetering, landlines, or autopilots.

For a prompt reply and a personal interview in your area, complete and mail the attached Professional Placement Inquiry today. If it has been removed, write to Mr. R. M. Smith, Industrial Relations Administrator-Engineering, General Dynamics | Astronautics, Dept. 130-90, 5691 Kearny Villa Road, San Diego 12, California.

LIBERAL ALLOWANCES ARE PROVIDED
MEN ASSIGNED TO FIELD OPERATIONS

GENERAL DYNAMICS | ASTRONAUTICS IS AN EQUAL OPPORTUNITY EMPLOYER.



GENERAL DYNAMICS ASTRONAUTICS

FORMERLY CONVAIR | ASTRONAUTICS

REACH WELDER for "blind" welds

This resistance welder is for use where critical spot-welded joints in stainless steels must be made by reaching long distances into small openings. It reaches 150 in. into an opening 3x8 in., says **Sciaky Bros., Inc., Dept. S/A, 4915 W. 67 St., Chicago 38, Ill.** The weld is made without the operator seeing the actual weld operation in the confined area.

The work piece becomes part of the welding machine, since reference guides are assembled in the structure prior to the welding.

No. 272 on Reader Service Card

WIRESTRIPPING TOOL for cramped areas

This wirestripping tool will handle a wide range of wire sizes and is equipped with an adjustable, positive lock for desired wire gage. The cam-action calibrated dial adjusts to strip from Nos. 12-26 wire gage size with a full range from 0.0-0.080 in., says **Utica Drop Forge & Tool Div., Kelsey-Hayes Co., Dept. S/A, Utica 4, N. Y.** The precision-built tool is designed to prevent wire nicking.

The tool is intended for use in limited-access areas, such as TV chassis, component parts, etc.

No. 273 on Reader Service Card

SOLDERING IRON is flexible

Midget soldering irons with improved performance owing to moving the heating element in the tip closer to the soldering surfaces are announced by **General Electric Co., Dept. S/A, Schenectady 5, N.Y.** Tip and heater assemblies can be changed faster and easier, the company said.

The irons are available in one-eighth to one-quarter inch tip sizes with six-volt, 18 to 35 W ratings.

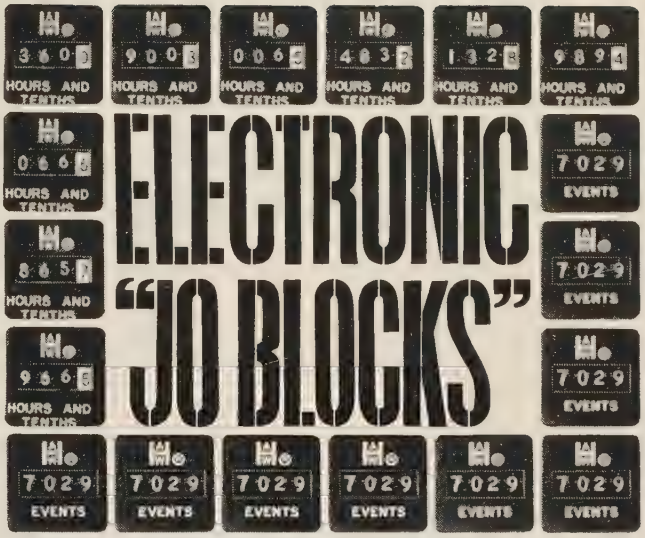
No. 274 on Reader Service Card

WELDING POSITIONERS for radar antennas

This positioning equipment was designed for final precision testing of bulky radar antennas. It is used principally to manipulate heavy and intricate pieces so that they can be tilted to any angle and rotated through a complete circle, according to **Ransome Co., Dept. S/A, Scotch Plains, N.J.**

All electrical equipment is weatherproof for outdoor installations. The unit is provided with dual operator's controls for operation from two stations.

No. 275 on Reader Service Card



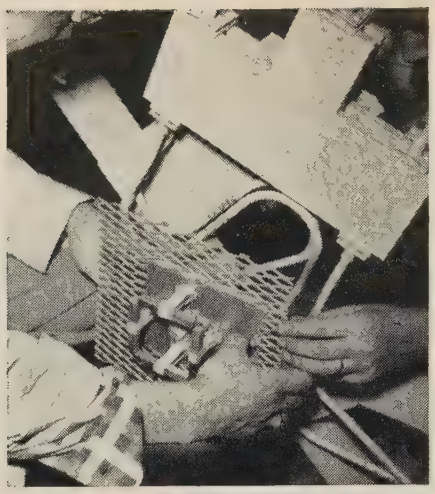
A. W. Haydon's microminiature elapsed time indicators and events counters are to electronics what "Jo Blocks" (Johanssen gages) are to metalworking —precisely accurate standards that are much more reliable than what they measure. Adapted from our earlier (and very successful) sub-miniature indicators, these microminiature timers have the unquestioned dependability that only A. W. Haydon's statistical production testing can provide...yet you can fit 100 of them into a 5" square ☐ We believe this new ETI is the world's smallest—only ¼ cubic inch. We know it is better than 99.9% accurate... exceeds requirements of MIL-M-26550...withstands 20g, 2000 cycles vibration...weighs only 0.75 oz.... temperature range is —65° to +250°F...and runs on a half watt, 115 v, 400-cycle power. Digital readout in hours, up to 999.9 or 9999. Companion events counters also provide 4 digit readout. Both of these units are available with a wide variety of compatible mountings ☐ For complete details on these tiny titans of time, or on any other electromechanical or electronic timing device to suit your special requirements, write The A. W. Haydon Company today.

THE AWH AYDON COMPANY

223 North Elm Street, Waterbury 20, Connecticut

Check Inquiry Form on Page 153

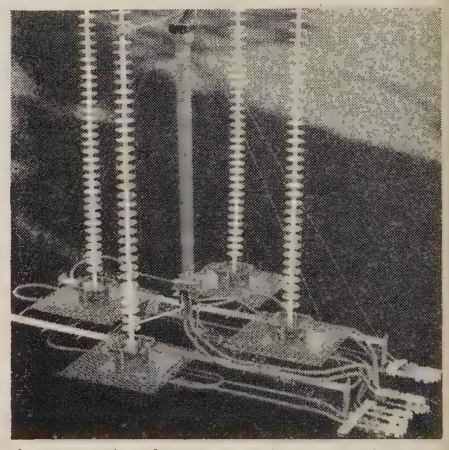
No. 86 on Reader Service Card



Individual unit assembly is first step in construction of antenna. Here four dipole antennas mounted on ground screen are being connected to one end of Foamflex feed lines. Special Phelps Dodge connectors are used to link the lines to the dipoles and four-way power dividers.

Completed quadrant elements, ready for placement on pedestal mount. Each quadrant is pre-assembled in exactly the same manner.

Completed quadrant elements are raised to platform for placing into position on pedestal mount.



An example of a center element unit that can be inserted into the Avien-Bogner array. This element forms a separate unit that can also be used as a portable ultra high frequency antenna.

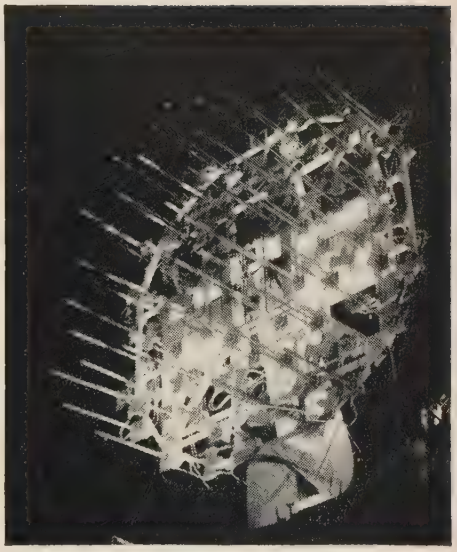
Foamflex® Coaxial Cable helps put and keep this advanced antenna system on the track!

A feed network of ⅜", 50 ohm Foamflex coaxial cable is a critical part of the fully automatic Avien-Bogner acquisition and tracking antenna that represents an advance in the state of the antenna art. The efficient operation of this sensitive antenna is greatly increased by the low loss, high phase stability and electrical uniformity of its weatherproof Foamflex feed line assemblies. Special connectors, designed and fabricated by Phelps Dodge, link the Foamflex lines to double-tuned, strip-line, four-way power dividers in each quadrant element of the antenna.

Designed for Edwards Air Force Base, this modular array is assembled from identical quadrants, each equipped with power dividers, dipole antennas and cigar elements. In contrast to the heavier, fixed-type paraboloids, the lighter, smaller Avien-Bogner model costs less, yet has high acquisition capability for telemetry information through the use of three automatic tracking modes. Quadrant elements may easily be replaced when changes are desired in frequency bands, due to the simple design and construction of this antenna.

The feed system was planned, fabricated, calibrated and installed by A-T Electronics, New Haven, Conn. Accurate uniformity of electrical length for each cable was maintained from cable to cable within one degree at 2200 megacycles after bending.

The outstanding qualities of semi-flexible, aluminum-sheathed Foamflex have been proved in a number of applications where low loss, long operating life and a low noise to high signal level ratio are essential. If your specifications call for a coaxial cable of the highest efficiency, we recommend you investigate the capabilities of Foamflex.



Self-tracking Avien-Bogner acquisition array has capability to telemeter data from vehicles traveling in the far reaches of space.

Center element unit is connected to the junction box of the Avien-Bogner antenna.

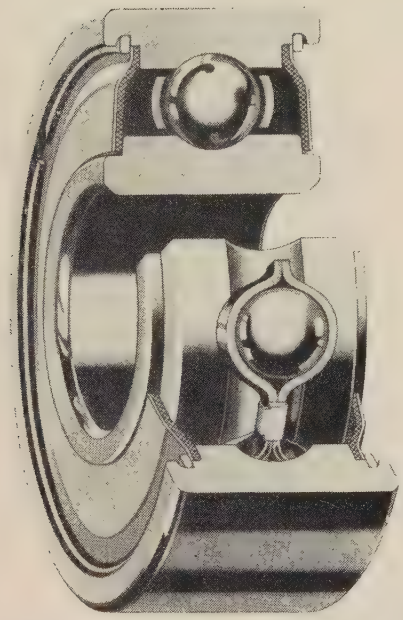
PHELPS DODGE COPPER PRODUCTS
CORPORATION
300 Park Avenue, New York 22, N.Y.

MINE TO MARKET P D

No. 87 on Reader Service Card

For details on equipment listed in this section, write in item number on Reader Service Card

SEALED PRECISION BEARINGS BLOCK CONTAMINATION



A new line of sealed bearings that effectively block out dirt and retain bearing lubricant while operating at high speeds in moderate to high temperatures is announced by the Barden Corp., Danbury, Conn.

The Flexeal bearing consists of a standard Barden precision bearing with a rubbing seal of fiber-aluminum laminate. The seal, installed in the shield groove of the bearing outer ring, seals against a ground surface on the bearing inner ring. Friction of the seal is negligible.

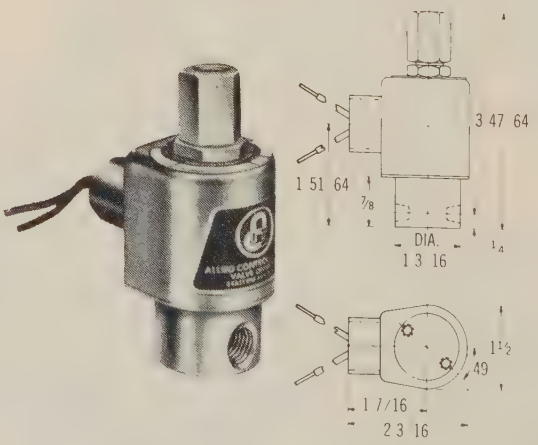
Flexeal bearings have been operated up to 3,000 hours at 80,000 rpm without damage or loss of efficiency. They have also tolerated lineal speeds of 6,000 fpm, compared to the usual 2,000-3,000 fpm toleration limits for most other sealed bearings. Operating temperatures range up to 300 deg F for continuous operation.

The bearings are currently in use in missile electric power units where they prevent loss of grease from bearings, in turbine fuel pumps to prevent entry of liquid fuel into the bearing, and in memory systems to seal out abrasive tape dust.

Flexeal bearings are particularly suited for use where neither shielded precision bearings nor less-precise sealed bearings provide sufficient reliability for mechanisms such as actuators, computers, generators, and motors.

Flexeal bearings are available in ten unflanged and three flanged sizes from 0.3125-2.4409 in. outside diameter. Prices are slightly higher than ABEC-7 shielded bearings. **76**

Miniature Brass Solenoid Valves Handle Pressures Over 0-200 psi



One of the smallest brass three-way solenoid valves currently available to handle differential pressures from 0 to 200 psi, or up to 500 psi for special applications, has been developed by Allied Control Company, Inc., 2 E. End Ave., New York 21, N.Y., for hydraulic and pneumatic service.

Cost of this new BM-300 Series miniature valve is lower than larger solenoid valves of comparable performance. It is available in normally-closed, normally-open, directional and free-venting versions.

A new design featuring improved flux path and heat dissipation has reduced the overall size of the valve while maintaining the same flow capacity and working pressure ranges of larger three-way solenoid valves.

The valve has an overall height of 3 47/64 in., and weighs approximately 15 oz. The standard BM-300 valves handle liquids and gases from —45 to 150 deg F, special models from —60 to 350 deg F.

The standard valve is bubble-tight to internal or external leakage, and special models are available for not over one micron leakage. Burst pressure is 6,000 psi. **75**

preview

Lightweight Electric Motor for B-70 Throttle Control

An electric motor that can operate in temperatures hot enough to melt the tires off an automobile has been developed by North American Aviation, Inc., Los Angeles Div., International Airport, Los Angeles 45, Calif.

Designed for use in a new electrical throttle-control system for the B-70, the lightweight motor can operate in a range of —65 to 550 deg F. The motor frame is stainless steel, with wiring encapsulated in ceramic and insulated by a unique aluminum-anodizing method developed by the company.

Use of the motor-powered electrical throttle system in the B-70 will mark the first time that a non-mechanical system has been designated as an aircraft's primary control. The principal advantage of the new system is that it won't be subject to the problems of structural deflections and varying temperatures encountered in various portions of the airframe during flight.

Fingertip Control of High Pressures

A new pressure-control device, affording fingertip control of pressures up to millions of pounds with only a spring-and-lever-controlled valve, has been announced by its inventor, Denis Farandatos, 120 Cedar St., New York N.Y.

The first application on the market uses CO_2 cartridges to open bottles. The device resembles a hypodermic syringe—the needle is inserted through the cork, forcing it out when carbon dioxide is released into the bottle.

The cartridge used is about 1500 psi. The device has been used with 5000 psi cartridges, and higher pressures can be used, according to the inventor. The unit can also be used with liquids.

Possible applications include use in oil cracking operations, precision control of air- or hydraulic-pressure cutting tools, autopilot servo controls, missile hydraulic drive controls, and various aircraft controls, such as opening cockpit canopies, emergency pressure applications, etc. A sample of the device is available from Scott H. Reiniger, The Bendix Corp., Bendix Int'l Div., 205 E. 42nd St., New York 17, N.Y. **66**

equipment in brief

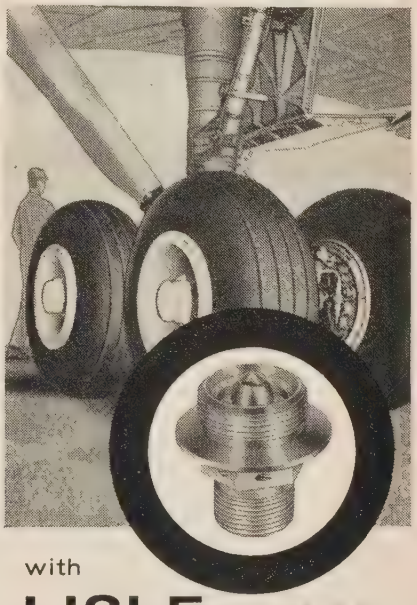
VALVE for rocket engines

A Flo-Ball main dual propellant valve that handles 12,000 lb of liquid oxygen and ammonia per minute at full throttle has been announced by **Hydromatics, Inc., Dept. S/A, 5 Lawrence St., Bloomfield, N. J.**

This valve and four others in the first and second igniter stages are said to make it possible for the pilot to control the engine, throttling from 25,000 to 50,000 lb thrust.

No. 251 on Reader Service Card

ENGINE FAILURE DETECTION BEFORE TAKEOFF!



with LISLE Magnetic CHIP DETECTORS

Detection of impending in-flight failure of engines, hydraulic systems, constant speed drives and other critical installations can be accomplished **before** takeoff, when it really counts!

Metal particles in an engine or accessory lubricant are a proven indicator of impending internal breakdown. The Magnetic Chip Detector attracts these particles which bridge an electrically insulated gap and complete a circuit which activates a warning light on the instrument panel.

Early detection means constant protection against in-flight failure.

Write for Catalog and Samples for Testing

LISLE CORPORATION
Clarinda, Iowa

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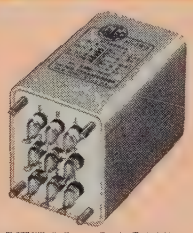
Transistor / Filament
SUPPLY
TRANSFORMERS
400 CYCLE TYPES

utc
PIONEERS IN MINIATURIZATION

Smallest METAL CASED

Immediate Delivery
FROM STOCK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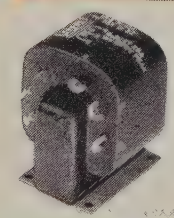

MOLDED

THESE units are designed for a wide variety of Transistor/Filament circuit applications. Conservative design plus rugged mechanical construction assure high reliability under the most severe environmental conditions. Power ratings are: Primary 28/115V, 380/1000 cycles; Secondaries 6.3V up to 25 amps; Test voltages up to 2500V RMS.

UNITED TRANSFORMER CORPORATION
150 Varick Street, New York 13, N. Y.
PACIFIC MFG. DIVISION
4008 W. Jefferson Blvd., Los Angeles 16, Calif.
EXPORT DIVISION:
13 East 40th Street, New York 16, N. Y.
WRITE FOR LATEST CATALOG

No. 89 on Reader Service Card

RECENTERING UNIT
meets Mil specs

A recentering mechanism, designed principally for returning to center the shafts of components such as synchrons, potentiometers, encoders, commutator switches, and gear trains, is manufactured by **MagneTec Corp., Dept. S/A, 7232 Eton Ave., Canoga Park, Calif.**

Designated the Series 1300, it is available in sleeve or ball bearing design, with standard servo-mounts or mountings designed for inclusion in the original design of components. Units are available with adjustable stops up to 320 deg rotation, and meet Mil specs, according to the manufacturer.

No. 276 on Reader Service Card

TRANSDUCER
for airborne use

A medium-to-high range pressure transducer, the Type 4-329, is described by its manufacturer, **Consolidated Electrodynamics Corp., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif.**, as the most accurate and sophisticated ever built for airborne use.

The instrument makes use of a rated electrical excitation of 20 V DC or AC rms with a carrier frequency in the 0-20 KC range. Sensitivity is 50 mv ±0.25 mv measured through a 50 K load at rated excitation and 70 deg F. Combined effects of non-linearity and hysteresis do not exceed ±0.35 per cent of sensitivity as measured from the best straight line through the calibration data, the manufacturer reports. Input impedance is 700 ohms minimum; output impedance is 350 ohms ±10 per cent at 77 deg F. Environmental specifications include a compensated temperature range of 30 to 250 deg F and an operable temperature range of —100 to 300 deg F.

No. 277 on Reader Service Card

PRECISION RELAY
has 0.048 cu in. volume

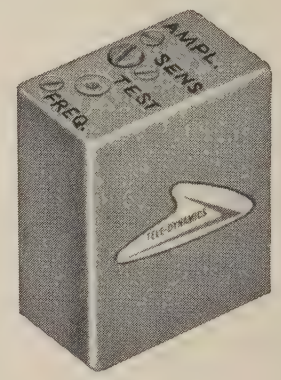
An extremely small precision relay that stands up under extreme conditions of vibration, shock, and temperature is offered by **Control Dynamics Corp., Dept. S/A, North Hollywood, Calif.**

Called the Dyna-Mite, it measures 0.2x0.4x0.6 in., and has a volume of 0.048 cu in., 1/16 that of a standard micro-miniature relay. It is hermetically sealed, and weighs 0.1 oz. The Dyna-Mite is being used in a major ICBM program, the manufacturer reports.

No. 278 on Reader Service Card

TELEMETRY BY TELE-DYNAMICS

Voltage Controlled Oscillator



Positive, reliable oscillator performance is essential to your aerospace telemetry needs. And Tele-Dynamic's newest—the Type 1270A Voltage-Controlled Oscillator is representative of Tele-Dynamic's creative effort in the complete telemetry field.

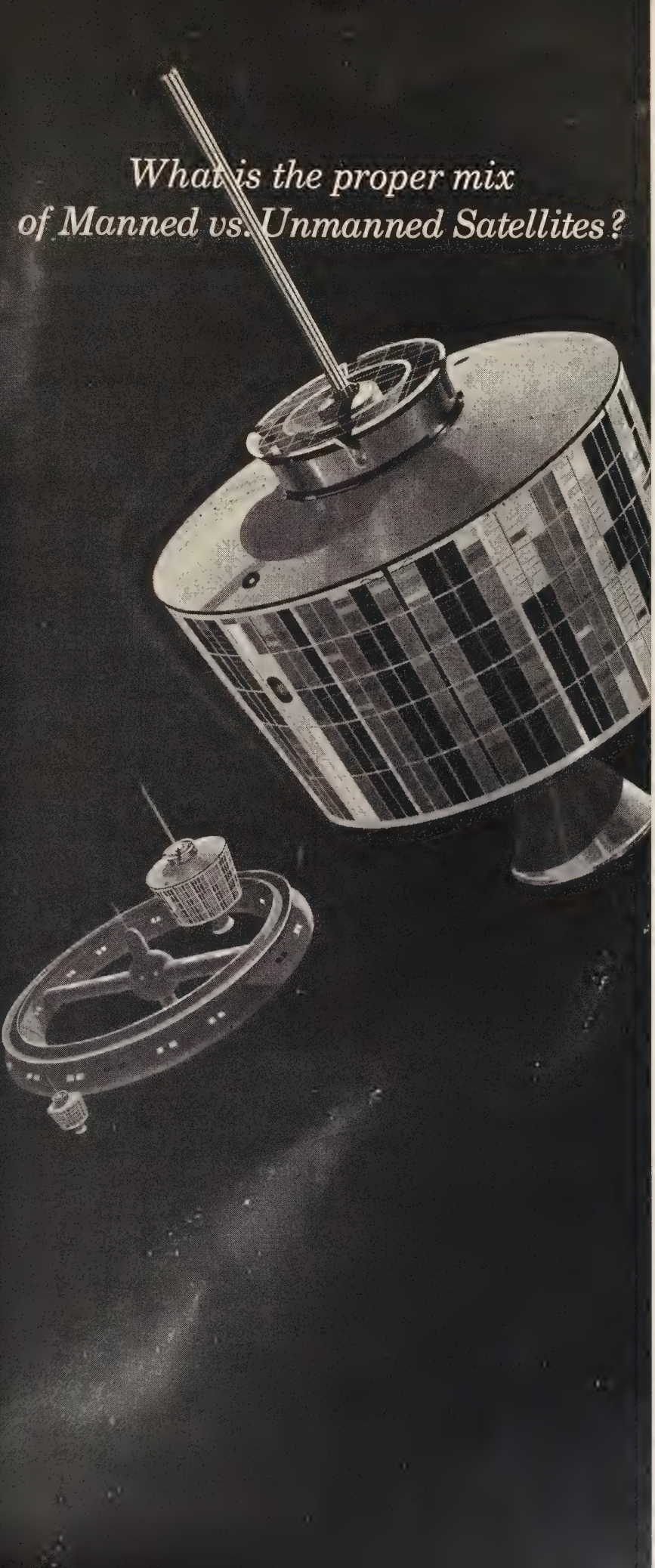
Characterized by excellent overall specifications, this new oscillator is high in electrical performance and environmental characteristics. Input 0 to 5 volts or ± 2.5 volts, linearity ± 0.25% best straight line . . . a power requirement of 28 volts at 9 milliamps maximum. Distortion is 1% and amplitude modulation 10%.

Environmental characteristics include thermal stability of ± 1.5% design bandwidth from —20°C to +85°C, unlimited altitude, 30G random vibration and 100G acceleration and shock. The 1270A weighs less than two ounces and has a volume of two cubic inches.

For detailed technical bulletins, call the American Bosch Arma marketing offices in Washington, Dayton or Los Angeles. Or write or call Tele-Dynamics Division, American Bosch Arma Corporation, 5000 Parkside Avenue, Philadelphia 31, Pa. Telephone TRinity 8-3000.

8411

TELE-DYNAMICS
DIVISION
AMERICAN BOSCH ARMA CORPORATION
5000 Parkside Ave., Philadelphia 31, Pa.



opportunities for

systems analysts

Hughes Aerospace Engineering Division has openings for Systems Analysts to consider and analyze a wide spectrum of basic problems such as:

What are the requirements for manned space flight?

Justify choice of systems considering trade-off of choice in terms of cost effectiveness.

Automatic target recognition requirements for high speed strike reconnaissance systems or unmanned satellites.

IR systems requirements for ballistic missile defense.

Optimum signal processing techniques for inter-planetary telecommunications.

Analysis of weapon systems from conception through development, test and customer use.

Design concepts for new airborne weapon systems.

The positions involved with the solution of these basic and critical questions present opportunities for the optimum application of the technical and analytical backgrounds of graduate physicists and engineers with both systems and specialized experience.

If you are interested in helping to solve these questions and are a graduate physicist or engineer with a minimum of three years experience in weapon systems analysis, operations analysis, IR, physics of space, signal processing or communication theory, we invite your inquiry. For immediate consideration, please airmail your resume to: **Mr. Robert A. Martin,** Supervisor, Scientific Employment, Hughes Aerospace Engineering Division, Culver City 85, California.

All qualified applicants will be considered for employment without regard to race, creed, color or national origin.

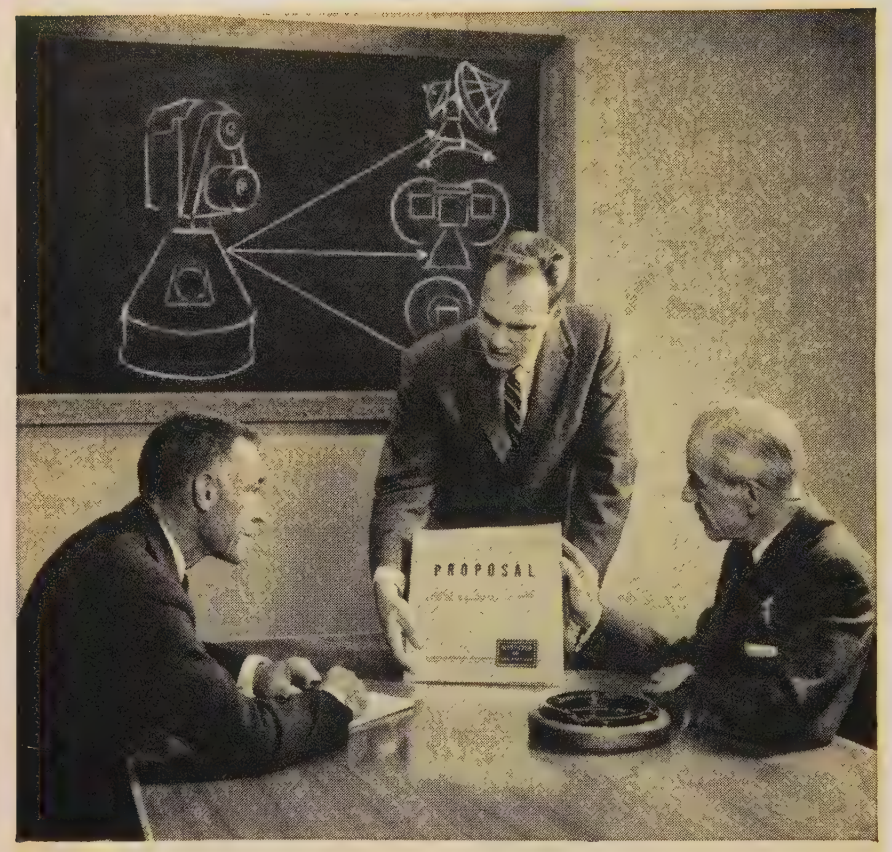
We promise you a reply within one week

HUGHES

HUGHES AIRCRAFT COMPANY

AEROSPACE DIVISIONS

ENGINEERING
REPORT
ON BENDIX COMPONENTS



HOW MUCH CAN BENDIX SAVE YOU IN ANTENNA PEDESTALS?

GET OUR SPECIFIC ENGINEERING PROPOSAL

Bendix experience in ground radar pedestal design, manufacture and installation can benefit *you*. It can meet your requirements without delay. Since basic design and tooling have already been accomplished, modifications, for your prototype needs, can be made quickly—and with important savings—or, we can design a completely new pedestal to meet your specific needs.

Bendix ground-installation radar pedestals are lightweight, compact, air transportable. They possess a high degree of accuracy, and have been completely proved in the field. Bendix also is widely experienced in airborne radar systems for weather and target tracking purposes.

If these demonstrated radar capabilities meet your needs, write today for further information, including a *specific engineering proposal*. What are your requirements?

EXAMPLES OF APPLICATIONS:

Weather Radar • Storm Detection • Meteorological Tracking • Mortar Tracking • Electronic Countermeasure • Satellite Tracking • Drone Surveillance • Telemetering

Eclipse-Pioneer Division
Teterboro, N. J.

THE Bendix CORPORATION

District Offices: Burbank, and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D.C.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

DIFFERENTIALS for computers, control

A line of subminiature precision differentials for critical applications in computer assemblies and control instruments has been announced by **Instru-Lec Corp., Dept. S/A, 520 Homestead Ave., Mt. Vernon, N. Y.**

Developed for strategic aerospace installations, the Instru-Lec two-spider-gear design features a ½-in. diameter swing (clearance circle) which permits extreme miniaturization, the manufacturer reports. The differentials are made entirely of stainless steel, with six miniature ball bearings that conform to ABEC 7 tolerance requirements. Backlash is held to eight min or less, break-away torque to 0.02 oz/in., and balance is maintained at all times, according to Instru-Lec. The differentials are available with either 0.0779 or 0.0935 in. diameter shafts with overall lengths up to 3 in. Pitch and number of teeth on end gears may be selected from a wide range.

No. 279 on Reader Service Card

FLEXIBLE COUPLINGS are miniaturized

These miniature flexible couplings are rated to transmit 15 to 40 in.-lbs of torque at high speeds. There are no moving parts, no friction, nothing to be lubricated, according to **Dial Products Co., Dept. S/A, 19 Cottage St., Bayonne, N. J.** They are torsionally rigid with no backlash. Finishes are to MIL specifications.

The line includes 12 models, including a ⅝ inch OD coupling in both pancake and split-hub types. Sizes range from ⅝ inch O. D. to 1 5/16 inch OD, and bore sizes from 0937 to .6875 in.

No. 280 on Reader Service Card

NUCLEAR TIMER is acceleration-actuated

An acceleration-actuated nuclear delay timer from **Leesona Moos Laboratories Div., Leesona Corp., Dept. S/A, 90-28 Van Wyck Expressway, Jamaica 18, N.Y.**, is reported to have a shelf and operating life of 10 years.

The Betachron Mod. D5307 unit is a new addition to a series of timers now operational in ICBMs. Small and lightweight, it delivers an electrical signal to the load when it experiences a particular uniaxial-acceleration vs time exposure. The device will not function unless the acceleration is applied in the proper direction and exceeds the specified minimum g-level for the specified time interval, the manufacturer reports.

No. 281 on Reader Service Card

No. 81 on Reader Service Card

SWITCH
for low pressures

A low pressure switch from **Pamar Electronics Co., Inc., Dept. S/A, 1 Tenakill Park, Cresskill, N. J.**, a Hoke, Inc., subsidiary, is reported to simplify the problem of sensing and indicating changes in low pressures.

The Hoke Pamar switch is designed to handle a maximum set pressure of 7 psig, and features a deadband of 2 in. of water and a repeatable accuracy of ±0.5 per cent. A Ni Span C capsular type sensing element is used to reduce any change in the pressure set point by thermal reaction over the operating range, —65 to 300 deg F, and to eliminate conventional connecting linkages. The switches weigh approximately 2 oz, and occupy 3 cu in. of space.

No. 282 on Reader Service Card

RIBBON CABLE
is flat, lightweight

This multi-conductor, multi-colored flat ribbon cable offers light weight, flexibility, ease of handling, full visibility of color code, says **Spectra-Strip Wire & Cable Corp., Dept. S/A, P.O. Box 415, Garden Grove, Calif.** It also provides control of inter-conductor capacitance, and uniformity in length of cable.

The insulation is PVC plastic. Gauges run from 10 AWG to 30, and practically any number of conductors. Shielded, coax, and thermocouples can be included.

No. 283 on Reader Service Card

NON-FRICTION BEARING
for aerospace uses

A compact non-friction device has been designed to replace ball bearing assemblies and jewels in many aerospace applications by **The Bendix Corp., Bendix Utica Div., Dept. S/A, 211 Seward Ave., Utica, N.Y.**

Called the Flexural Pivot, the new bearing is described as a simplified version of the cross-spring pivot, offering package design and easy installation. It features flat steel springs that form a web between two separated "halves" of a tubular bearing. The flexing of the springs allows movement—up to a 60-deg arc—with no rubbing of one part against another. The Flexural Pivot has been successfully tested for applications in missile altitude control devices, rocket-steering units, autopilot altitude-control elements, gyros, air data sensors, scale mechanisms, computer magnetic recording units, scales, and recording galvanometers, Bendix reports.

No. 284 on Reader Service Card

FLOW TRANSDUCERS
for use in missiles

A line of flow transducers for use in missiles using thrust vector control is offered by **Standard Controls, Inc., Dept. S/A, Seattle 44, Wash.**

The Series SF2 transducers have ranges of 0 to 0.5 gps through 0 to 200 gpm. For telemetry systems, a signal conditioning amplifier can be incorporated into the transducer to provide a 5 V full scale output. Design consists of a full bridge system with four active bonded strain gage sensing elements that sense flow force on a cantilever reed in the flow stream. All electrical circuitry is said to be consistent with standard strain gage techniques. Sensitivity is 4 mv/volt. Flow is undirectional. Linearity is two per cent of full scale. Repeatability is less than 0.25 per cent. The transducer is described as having no rotating parts, and no bearing or hinge action, with cantilever bending movements and infinite resolution that permits accurate sensing down to zero flow. It weighs 8 oz, and measures 1¼x1x4 in.

No. 285 on Reader Service Card

POPPET VALVE
for high temperatures

A high temperature poppet valve designed to operate at 950 deg F is available from **Barber Colman Co., Aircraft and Missile Products Div., Dept. S/A, Rockford, Ill.**

It is offered with a radiation resistant solenoid for special applications in which radiation is likely to occur. Typical specifications for a one-in. valve are: maximum operating pressure, 265 psig; internal leakage, 0.04 lb/min at 265 psig and 530 deg F; weight, 1.85 lb. Other sizes can be designed to meet specific requirements.

No. 286 on Reader Service Card

GYRO SPIN MOTOR
has encapsulated stator

An epoxy encapsulated stator and external rotor with cast aluminum squirrel cage are features of the Model 108 gyro spin motor offered by **Curvin Development Co., Dept. S/A, 13740 Saticoy St., Van Nuys, Calif.**

The Model 108 can be supplied to operate on two-or-three-phase, 400-cycle power, or on single phase power with an external capacitor. The manufacturer reports that it accelerates a 480 gm/cm² inertia ring in 50 sec, and operates at 23,000 rpm with six watts of power. Its dimensions, excluding the inertia ring, are 1¼ in. OD x ¾ in. long.

No. 287 on Reader Service Card

ENGINEERING REPORT ON OTHER BENDIX COMPONENT PACKAGES

PRECISION DATA AND CONTROL SYSTEMS FOR LARGE RADAR ANTENNAS

Through intensive research and development for major programs, Bendix offers a wealth of design experience in both digital and analog radar control and data systems. We can:

1 Develop *complete systems or subsystems* to comply with any customer requirement.

2 Provide a wide range of installation options, i.e.: one antenna or a battery; control of one radar by another; digital or analog control. Systems with accuracies of .005° or better can be offered.

Manufacturers of

GYROS • ROTATING COMPONENTS
RADAR DEVICES • INSTRUMENTATION
PACKAGED COMPONENTS

Eclipse-Pioneer Division

The Bendix Corporation

Teterboro, N. J.

No. 90 on Reader Service Card

U.S. Radium presents...

dials, panels and nameplates

Edge-lighted Lackon® panels
Embedded circuit panels
Screen-marked tapes
Lithographed and etch-marked dials, panels and nameplates/Bulletin 10.30 B

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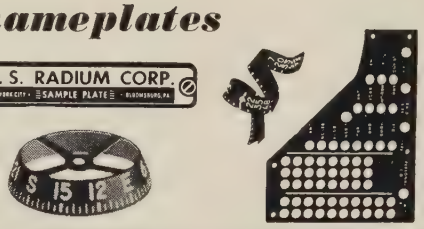

radiation sources

Sealed beta, gamma and neutron sources/Bulletin 20.40 B
Ionization sources for electron tubes/Bulletin 13 B
Alpha calibration sources/Bulletin 20.80 B
Tritium foils and targets/Bulletin 20.70 B

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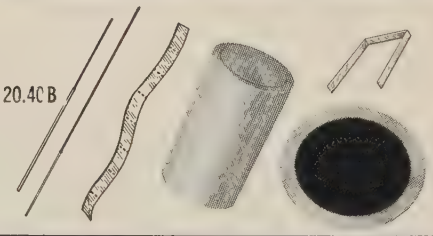

isolite light sources

Radioisotope-excited, self-luminous markers, signs, placards, etc./Bulletin 30.31 B
Tritium-excited luminous compounds
U.S. AEC byproduct material license No. 37-30-6 (C 63)

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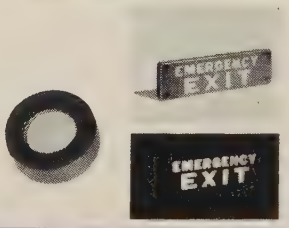


phosphors

Undark® self-luminous compounds/Bulletin 1.1P B
Helecon phosphorescent and fluorescent pigments/Bulletin 65-600 B
Radelin® cathode ray tube phosphors/Bulletin 40.61 B
Thermographic phosphors/Bulletin 40.40 3
Electroluminescent phosphors/Bulletin 50.10 B
Product identification phosphors/Bulletin 40.50 B

No. 94 on Reader Service Card

geiger-mueller tubes

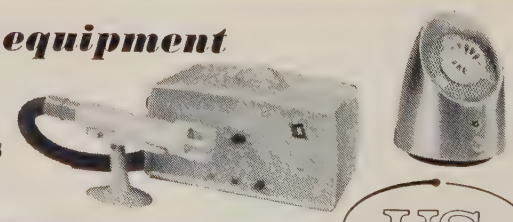
In stock—highest quality, economically priced G-M tubes distributed exclusively in USA for Electronic Associates Limited of Canada /Bulletin EAL B

No. 95 on Reader Service Card

ion generating equipment

Selective ion generators/Bulletin 60.30 B
Dynamic Ionaire® Mark VII negative ion generator/Bulletin 60.23 B

No. 96 on Reader Service Card



US RADIUM

united states radium corporation

MORRISTOWN, N. J. | Offices: Chicago, Illinois and North Hollywood, Calif. Subsidiaries: Radelin Ltd., Port Credit, Ont., Canada and U.S. Radium Corp. (Europe), Geneva, Switzerland.

COOLING PACK for miniature equipment

An airborne heat transfer system from **Eastern Industries, Inc., Dept. S/A, 100 Skiff St., Hamden 14, Conn.,** designed to cool electronic countermeasure equipment that is miniaturized to the point where neither convection nor fan cooling is adequate.

Designated E/HT-200-214, the new unit has a capacity of 3400 W and maintains the ethylene-glycol-water coolant between 150 and 170 deg F by means of a temperature regulating valve, the manufacturer reports. The cooling pack is designed for operating temperatures from −55 to 55 deg C, and performs from sea level to 50,000 ft. It weighs 25 lb, measures 4.6x10x20 in., and requires a power supply of 208 V, three phase, 400 cycles.

No. 288 on Reader Service Card

SENSING ELEMENT is gravity-sensitive

This electromagnetic vertical sensing element is a gravity-sensitive, liquid-damped, pendulous device which can be applied to any vertical sensing situation requiring an electrical output. It operates from a standard power supply, says **Kearfott Div., General Precision, Inc., Dept. S/A, Little Falls, N.J.** Utilized in a servo system, it can initiate self-alignment of a gyro platform or it may be used solely as a true pitch and roll indicator.

A frictionless wire-suspended mass acts as the moving portion of two orthogonally mounted differential transformers to provide a phase-sensitive output signal proportional to tilt angle.

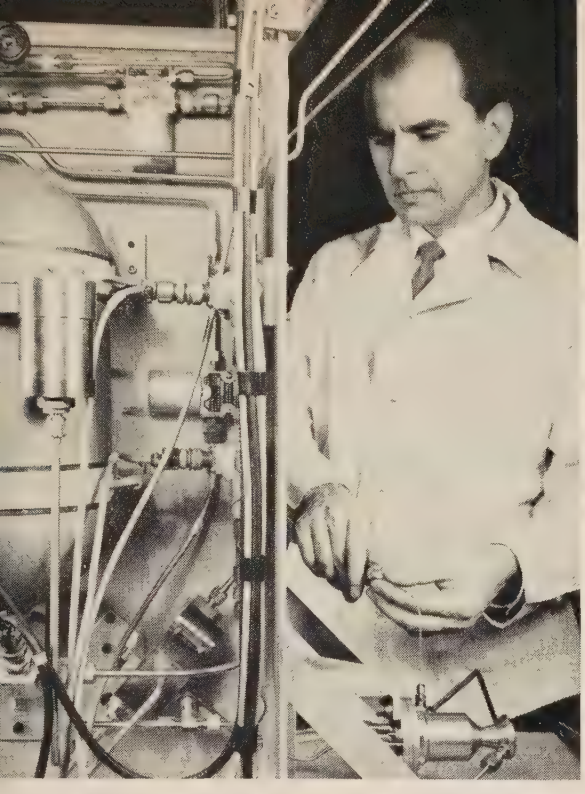
No. 289 on Reader Service Card

SWITCH has rotary linkage lever

A high-temperature, hermetically sealed switch with a rotary linkage actuator has been announced by **Micro Switch Div., Minneapolis-Honeywell Regulator Co., Dept. S/A, Freeport, Ill.**

The manufacturer reports that the switch is designed to operate in temperatures from −65 to 600 deg F, and can be used near jet afterburners, missile exhausts, and in other high-temperature air and missile applications. The switch is also said to provide positive actuation and release regardless of adverse dirt and ice conditions. It carries a two-amp inductive rating at 28 V DC, and a one-amp inductive rating at 115 V AC, 60/400 cps.

No. 290 on Reader Service Card



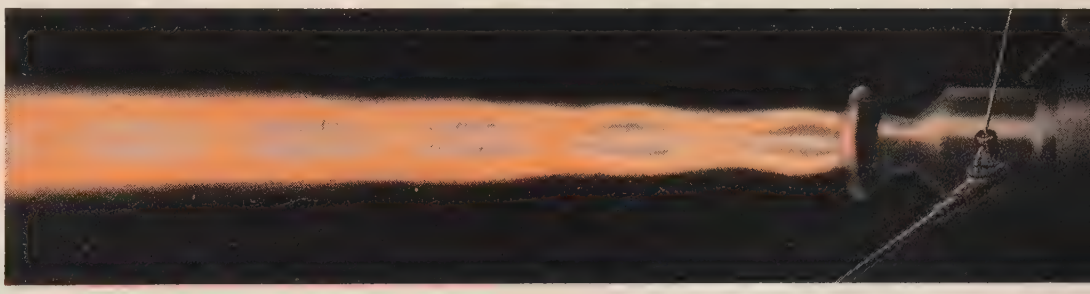
Special test facilities developed by Vickers Research and Development teams are used to evaluate nozzle designs, fuels, controls, instrumentation, etc. This setup is used in hypergolic bipropellant studies.

CAPABILITY
is spelled
a-t-t-i-t-u-d-e
c-o-n-t-r-o-l

Selection of the optimum attitude control system for a particular missile or space vehicle requires special technical skills, facilities for conducting the necessary test program, and knowledge solidly based on related experience. All these are available "in quantity" at Vickers.

Actual experience dates back to hot gas servo studies initiated in 1955 and now covers the additional areas of hydrogen peroxide-powered reaction control, hypergolic bipropellants and secondary injection systems using either liquid (freon), or hot gas bled from engine combustion chambers.

The facilities and skills responsible for these developments in attitude controls are available to you as a vital aid in solving the problems of space-flight orientation. For more details, write for Bulletin A-5264, and/or call the Vickers' Application Engineer in your area. He is a thoroughly experienced practitioner in the "Programed Power"* field.



Nozzle designed for hypergolic bipropellant shown under test, flame temperature 5800°R. Exhaust flame is characterized by well defined series of shock diamonds.

AERO HYDRAULICS DIVISION
VICKERS INCORPORATED
DETROIT 32, MICHIGAN
TORRANCE, CALIFORNIA

division of
SPERRY RAND
CORPORATION

*PROGRAMED POWER IN:

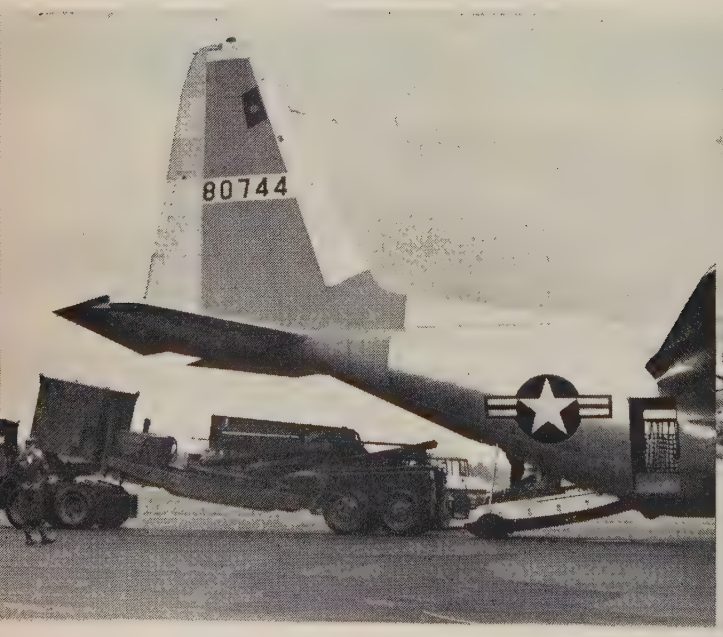
POWER TRANSMISSION
ENERGY CONVERSION
FLUID TRANSFER

Space vehicle simulator used in development of attitude control systems weighs 2 tons, yet can be set in motion with a finger touch. Entire unit is supported on a 3-inch steel ball that floats on a hydrostatic bearing and is free to move in three planes: pitch, yaw and roll.

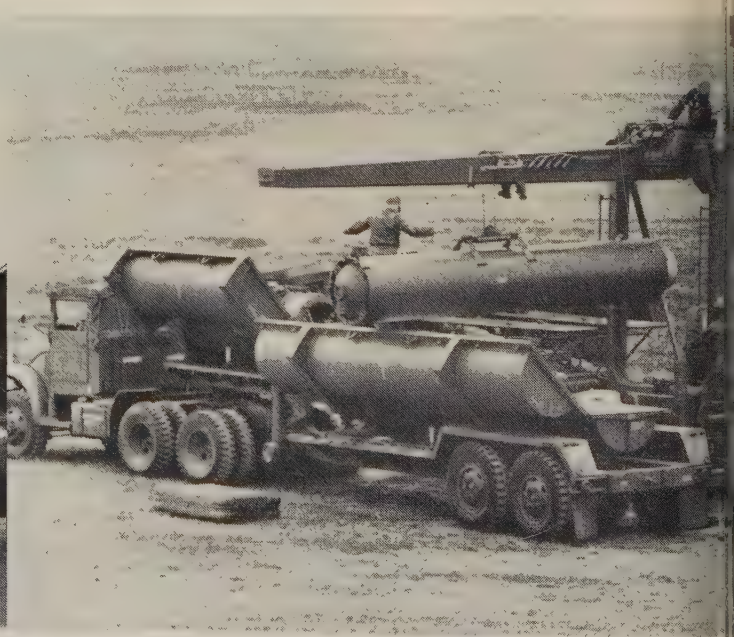
No. 97 on Reader Service Card

Half-mule, half-bird The U.S. Army's Sergeant, now in production, is artillery, and it can traverse terrain where caissons used to go rolling along. And for long, fast hops, the Sergeant can readily be airlifted. The prime contractor, Sperry Utah, wisely selected new, light gages of USS "T-1" Constructional Alloy Steel with 100,000 psi yield strength for the ground support special purpose equipment. USS "T-1" Constructional Alloy Steel is three times stronger than structural carbon steel, thus fabricated components can be made thinner and lighter with no sacrifice in strength. The entire launcher is air-transportable because it weighs only 16,000 pounds—7,000 pounds less than if built with structural

Steel "Keeps America's strength high."



Wide use of USS "T-1" Steel makes the transporter-erector-launcher 7,000 pounds lighter and completely air-transportable.



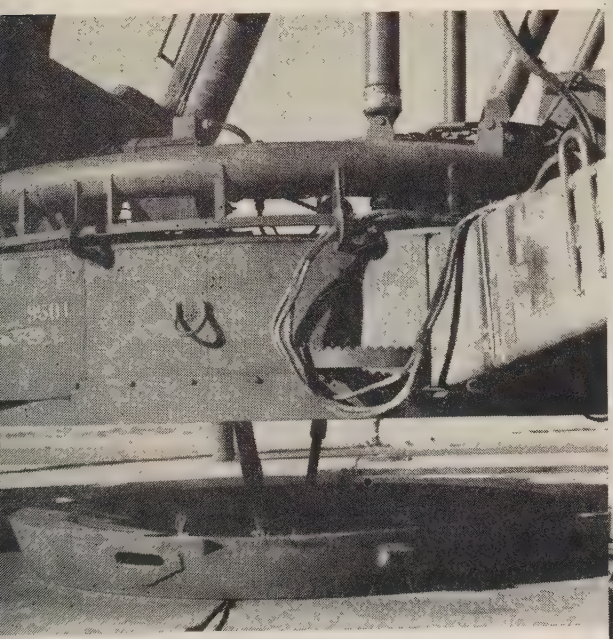
Frame components of special purpose container transport trailers are "T-1" Steel; launcher boom is also "T-1" Steel, for maximum strength and minimum weight.

All major structural components were designed at an allowable working stress of 66,700 psi.

carbon steel. When your missile support system goes on the drawing board, you can obtain applications and development assistance by consulting the one producer of all basic materials for support hardware and facilities. Whether it's carbon steel or special constructional alloy steels, electrical cable or wire rope...consult

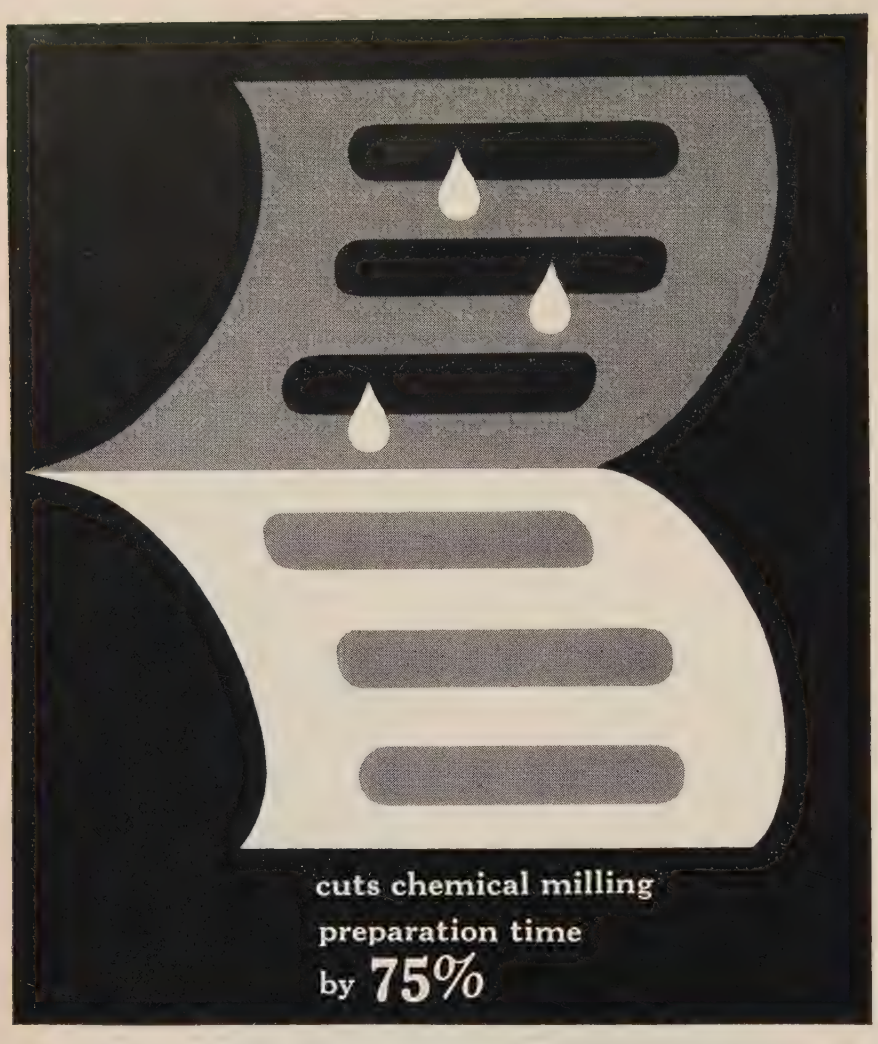
United States Steel

USS and "T-1" are registered trademarks



diameter welded USS "T-1" Steel tubing forms the us ring of the launching superstructure.

USS "T-1" Steel outrigger legs stabilize the unit in firing position. Also made of "T-1" Steel are the U-frame, extension arms, top and rear tension members and back beam.



MYSTIK BRAND

7300 MYLAR MASKING TAPE

■ Here is a pressure-sensitive tape that will save time and money in your chemical milling operations. Mystik No. 7300 Mylar tape is quickly and easily applied to the surface to be masked off, and can be put on in ¼ of the time it takes to mask by spray-coating. No. 7300 not only saves valuable time, it allows for pin-point milling accuracy. The reason is the tough silicone adhesive. It grips ferrous and non-ferrous metals tightly during the entire milling process and shows excellent resistance to etching solutions. Thus, accurate milling is assured, right to the masked edge.

Get full facts on how Mystik No. 7300 Mylar tape can save you time and money, and give you greater milling accuracy. Write us today about No. 7300 and the full line of Mystik Brand Tapes.

MYSTIK® TAPE SELF-STIK

MYSTIK ADHESIVE PRODUCTS, INC.
2635 N. KILDARE AVENUE • CHICAGO 39

POWER PACKAGE produces thermoelectricity

A new power package from **Harco Laboratories, Inc., Dept. S/A, New Haven, Conn.**, is said to produce usable thermoelectricity for dozens of applications using low-power output.

Designated the Seejen, it produces electricity directly from heat. Any number of Seejens can be connected in series-parallel or other combination into any configuration to create compact generators called Seejenators. They thus provide a wide variety of voltages, resistances, and currents. Each Seejen measures 6x1½x⅜ in., and weighs 1½ oz. Resistance is 100 ohms; voltage at 200 deg F differential is 1 V; power output is 2.5 milliwatts, and current into 100 ohms is 5 milliamperes. The units are priced at $4.95 each.

No. 291 on Reader Service Card

MISSILE GYRO is spring powered

This spring-energized gyro is designed for short duration missiles. It reportedly has a run-down time of seven to nine minutes and reaches full speed of 3330 rpm in 100 msec. **Model Engineering & Mfg. Corp., Dept. S/A, Boyne City, Mich.**, says that the measured drift after 30 sec of operation is less than one degree for the outer gimbal and less than six degrees for the inner gimbal. Both gimbals have 360 deg of freedom.

The gyro weighs about 3-¾ lb, is 5 in. long by 4.2 in. diameter. It has segmented pickoff commutators on the outer gimbal for roll reference information. The company claims the gyro will give full performance for at least 100 firings.

No. 292 on Reader Service Card

SOLENOID VALVE has no organic parts

A solenoid-operated shut-off valve with no organic parts is offered by **Polymet Co., Dept. S/A, P.O. Box 321, Orange, N. J.**

The ⅛-in. valve is also said to feature lightweight construction, straight-through flow with little pressure drop, and low electrical power requirements. Its unitized body of aluminum and stainless steel integrates the line connection, chamber, seats, and plunger sleeve, reducing number of assembled parts and eliminating maintenance problems caused by organic seals. The manufacturer reports that the valve can be used over a broad range of temperatures and pressures, and with a wide variety of fluids.

No. 293 on Reader Service Card

No. 98 on Reader Service Card

RING GEAR FOR OUTER SPACE:

NDIX THRUST CTOR CONTROL STEMS

IDARY INJECTION: Newest way to the turns'' in outer space. x is now heavily engaged in research velopment work on systems to steer s and other missiles and spacecraft. vork involves the study and mecha- on of means for deflecting the rocket jet by means of liquid and gas on.

BLE NOZZLES: Proved Bendix sys- embodied in the Minuteman am. Responding to signals from the e's "message center," nozzles move ange direction of the thrust, and , of the rocket. Test firings have d this system's reliability, time after The Bendix system saves 40% in t compared with previous test sys- and has low actuation torque ements.

d contractors are invited to write for further tion. Write: Bendix Products Division—Aviation, Bend 20, Indiana.

dix PRODUCTS DIVISION South Bend, IND.

THE Bendix CORPORATION

No. 99 on Reader Service Card

Correct tension, that is, of bolts, studs, screws, and other fasteners used in product assembly. Without tension control there is no quality control.

For example, uneven tightening of head bolts causes warping and engine trouble. Improper tension of fasteners in aircraft components sets up dangerous stresses and strains. Measuring devices, electronic components, frames, fittings, high-pressure containers — these and many other products require uniform tension on screws and bolts for proper operation.

That is why SNAP-ON® Torqometers® are being used more and more on assembly and maintenance work. These precision wrenches tighten bolts and studs to exact predetermined tensions. Or they may be used to spot check the tension on bolts tightened with power impact tools. Easy-to-read dials show torque measurement in either inch-pounds or foot-pounds.

SNAP-ON offers Torqometers in a wide range of sizes, plus torque drivers for proper tensioning of screws. These are widely used in electronic and electrical assembly.

If exact tension on fasteners is part of your quality control, or if you suspect that lack of such control may be a source of trouble, call in a SNAP-ON Sales Engineer. He can offer qualified advice on torque-measuring problems, and provide a complete range of hand tools and wrenches for assembly or maintenance. Write us or call your nearest SNAP-ON Branch.

FOR ALL INDUSTRY

SNAP-ON TOOLS

8080-I 28th AVENUE • KENOSHA, WISCONSIN

MINIATURE SWITCHES have four circuits

Two four-circuit designs have been added to the line of sealed miniature limit switches available from **Minneapolis-Honeywell Regulator Co., Micro Switch Div., Dept. S/A, Freeport, Ill.**

The switch enclosures, which measure 1x2½ in., are sealed completely to protect switch elements. O-ring seals, glass-to-metal terminal seals, and potted leads are used to prevent moisture, dust, or air from getting inside. The switches are available in two actuator designs, a plunger model for in-line operating motion and a positive-drive rotary linkage unit for operation under adverse dirt and ice conditions. They are rated at 24 amp maximum inrush and 7 amp resistive at 28 V DC. Prices range from $45 to $65, with quantity discounts.

No. 294 on Reader Service Card

POWER PACKAGE has integrated pump motor

Overall efficiencies as high as 64 per cent are reported for a lightweight hydraulic power package for airborne applications developed by **Hydro-Aire Co., Dept. S/A, 3000 Winona Ave., Burbank, Calif.**

The unit incorporates an integrated pump-motor design. It weighs 4 lb, and measures about 4x4x7 in. It consists of a fixed displacement pump driven by a DC motor operating at a nominal speed of 12,000 rpm. Rated delivery of the pump is 0.34 gpm minimum at 3250 psig over a voltage range of 25.5 to 30 V DC.

No. 295 on Reader Service Card

TRANSDUCER operates under water

A general-purpose underwater transducer has been developed by **Clevite Corp., Ordnance Div., Dept. S/A, 540 E. 105 St., Cleveland, Ohio.**

The Clevite Oyster is designed to operate at up to 60 psi water pressure, and over a frequency range from 10 to 10,000 cps. Below resonance, its response is a constant 82 db, reference 1 V per microbar (—90 db into 60 ft of coaxial cable.) It is substantially nondirectional over its normal frequency range, the manufacturer reports, and can be used as a transmitter as well as a receiver. With 60 ft of cable, the Oyster weighs 11 oz with brass or 9 oz with aluminum pistons, and is 1¾ in. in diameter x ½ in. thick.

No. 296 on Reader Service Card

No. 100 on Reader Service Card

No. 165 on Reader Service Card

Reliable Rodney Says: THERE'S NOTHING NEW UNDER THE SUN

Honeycomb is old stuff to the bee. He's been using it from time immemorial. It took man's ingenuity to recognize it as one of the strongest yet lightest methods of fabricated construction. The solution is not that simple, though, when applied to making honeycomb for the aircraft and missile industry.

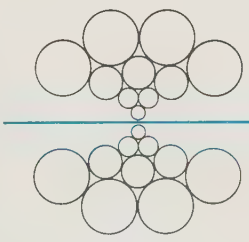
esides the problems of strength, weight, heat resistance, ratio of ace area to volume, there is the critical requirement of maintain- niform thickness of the stainless steel and high temperature alloy used to make this sandwich structure.

his area of precision rolling is where Rodney leads the industry. e age alloy foils are being rolled to super thin tolerances in the st strips available anywhere. We can do this at Rodney because ioneered in the development and use of special equipment and niques. Our *two* Sendzimir mills, equipped with continuous, contact thickness gauges, roll accurate foils in widths up to nches. Our continuous bright annealing lines process foils in the st strips available anywhere. In addition, precision slitters, acid ning lines, and various types of visual and instrumented inspec- lines give us a leading position in this industry.

To further refine our specialization in producing the thinnest and widest strip available, we maintain a modern laboratory for quality control, research, and development. These laboratory facilities and our technical experience in this field are available for the solution of your special problems.

An illustrated brochure is available on request.

STAINLESS STEELS • HIGH TEMPERATURE ALLOYS • EXOTIC METALS (Refractory)



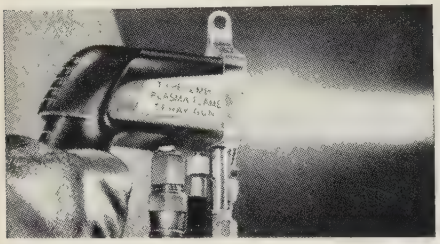
RODNEY ROLLED IS QUALITY CONTROLLED

RODNEY METALS, INC. MILL: NEW BEDFORD, MASS.

Vest Coast Office and Warehouse: 5462 East Jillson St., Los Angeles 22, Cal.

NOW—
Plasma flame sprayed coatings with precisely controlled characteristics

You can apply coatings of high melting point materials such as tungsten, alumina, zirconia, other refractory materials and a wide range of metallics.



New METCO Plasma Flame Spray System permits precision control of a wide range of coatings, and exact duplication of desired results.

Features of improved plasma flame spray system

GUN Nozzle and electrode positions fixed and foolproof. Nothing to adjust. Light for manual use; sturdy for machine mount. Compact: can operate inside 5" bore. Sprays up to 15 pounds per hour. Can be used with nitrogen, argon or helium, with simple nozzle change. 6-piece construction.

POWDER FEEDER Extremely accurate and consistent powder feed rates. Calibrated control permits exact duplication of coatings. Powder feeds without flutter, regardless of particle size, wear of parts, or amount in hopper. Operates at atmospheric pressure, refillable with gun in use. Hopper removable with twist of wrist; contains non-spill valve.

CONTROL UNIT Push button controls are mounted in modular design cabinet, with fail-safe features.

The new plasma spray system is 100% a METCO design, engineered for flame spraying only. Both METCO equipment and materials are backed by METCO's technical service in the field and at headquarters. For detailed information on the new equipment and unique characteristics of METCO materials, send for Plasma Bulletin No. 16.

METCO INC.
FORMERLY METALLIZING ENGINEERING CO., INC.
Flame Spray Equipment and Supplies

1133 Prospect Ave., Westbury, L. I., N. Y.
Telephone: Edgewood 4-1300 Cable METCO In Great Britain: METCO LTD., Chobham-near-Woking, England.

BOOTH 645
AMERICAN ROCKET SOCIETY
N.Y.Coliseum
October 9-15

METCO: Please send me free bulletin on METCO Plasma Flame Spray System.

Name
Title
Company
Address
City Zone State

No. 233 on Reader Service Card

PHOTOTRON CONVERTS angular to digital data

This phototron, used for incrementally converting shaft angle to digital measurement information, is available in seven models. Associated power supplies and binary and digital counters will soon become available, reports **Hydro-Aire Co., Dept. S/A, 3000 Winona Ave., Burbank, Calif.** Maximum speed capacity varies from 15,000 rpm at 128 counts per revolution to 1250 rpm at 2048 counts.

Rate information may be taken at the same time as quantity in either a CW or CCW direction. The phototron weighs 19 oz, is 4.68 in. long, and has a diameter ranging from 2.75 to 3.5 in. The shaft on all models is 0.25 in. diameter.

No. 297 on Reader Service Card

SEALED CELLS for electronic systems

Sealed silver-cadmium cells to meet the power requirements of satellites, portable communications, and other electronic systems that demand maintenance-free operation, high capacity, and long life are available from **Yardney Electric Corp., Dept. S/A, 40-52 Leonard St., New York 13, N. Y.**

The manufacturer reports that development of these cells was made possible by a new method that attains maximum recombination of generated gas. Sealed Silcad cells are manufactured in ranges from 0.0 to 300 amp/hr. Their energy output is 25-39 W/hr per lb, and 1.6 W/hr per cu in. over a range of discharge rates. They have a life of 300 to 1000 deep cycles, depending on the application.

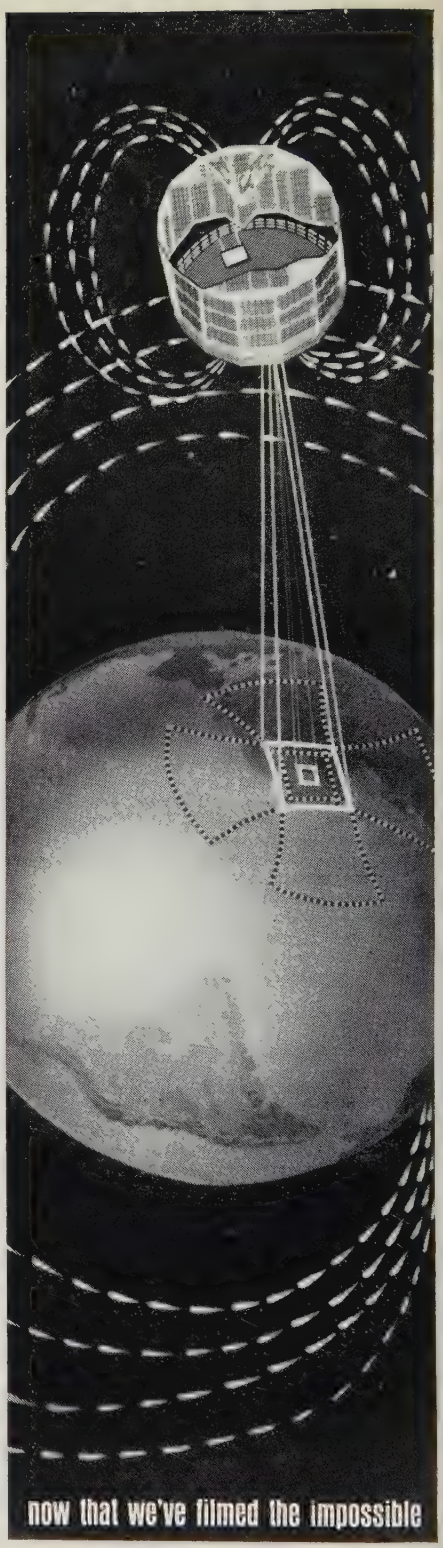
No. 298 on Reader Service Card

AUXILIARY MOTOR for missile environments

High power-to-weight ratio and over-all efficiency of 75 per cent are claimed for a special purpose, limited duty cycle, DC electric motor for missile environments offered by **Task Corp., Dept. S/A, 1009 E. Vermont Ave., Anaheim, Calif.**

The motor weighs 6.7 lb, and produces 3.25 hp at 13,700 rpm using 30 V DC power, according to the manufacturer. Use of lightweight radio noise filters is made possible by improved commutation and attendant low electrical noise level. For extended operation, the motor can be adapted for force ventilation cooling. High temperature materials are used throughout.

No. 299 on Reader Service Card



what can we do for you?

We had the answer for TIROS...for NIMBUS. We've had the answer to movie camera, still camera, X-ray camera and aerial camera problems. We've had the answer to problems of **high** volume-**low** unit costs; we've had the answer to problems where few-of-a-kind are involved. If your company is facing an optical design problem, Elgeet's engineering and design section welcomes the challenge to create the breakthrough that you require.

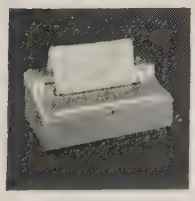
Write: Elgeet Optical Company, 838 Smith St., Rochester, N.Y.

Elgeet EL-63

No. 234 on Reader Service Card

STANCE: Litton Systems Advance the Defense Posture of the Free World

The need is urgent. It will be met. By free men acting with renewed faith. Armed by advanced in-being systems such as those to be displayed at the Litton Systems booth at the Air Force Association show this month. You are invited to see them. To study the Litton record of system management and technical creativity for USAF and other defense forces of the free world. To evaluate the meaning of that record in relation to our present and future defense posture.



LITTON SYSTEMS, INC.
BEVERLY HILLS, CALIFORNIA
A DIVISION OF LITTON INDUSTRIES

Guidance & Control Systems • Computer Systems • Command and Control Systems • Space Science
Bioelectronics • Westrex Communication and Data Recording Systems • Electronic Countermeasures

The spectrum to systems career opportunities is broad at Litton. All qualified applicants will be considered regardless of race, creed, color or national origin.

NEW Electro Magnetic Pickups

BREAK THROUGH HIGH TEMP. BARRIER

...operate from −300° to +800°F.

3100 series pickups safely withstand extreme heat

- inside compressor chambers of jet engines.
- in high temperature flow meters.
- under extremely hot oil during thermostat testing.
- in missiles where extreme temperatures are a problem.

A self-generating frequency source . . .

pickups convert mechanical energy to frequency/voltage in proportion to speed of ferrous metal objects interrupting their magnetic fields. Need no physical contact with exciting metal.

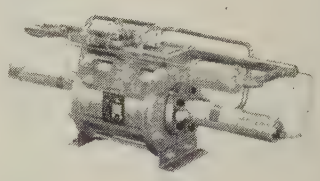
Write for Bulletin CMP-50 and Name of Your EPL Representative

Electro CHICAGO

ELECTRO PRODUCTS LABORATORIES
4501-C Ravenswood, Chicago 40
Canada: Atlas Instrument Corp., Ltd., Toronto, Ontario

No. 101 on Reader Service Card

COMPRESSORS boosts gas to 10,000 psig



80 to 150 psig plant air pressure can now boost bottled gas up to 10,000 psig without water barriers, hydraulic barriers or diaphragms for isolation of the gas system, says **Haskel Engineering & Supply Co., Dept. S/A, 1236 S. Central Ave., Glendale 4, Calif.** This is made possible by means of their new air-cooled model AG series plant air-driven oil-free gas booster compressors.

The units are available in single stage for up to 6:1 compression ratio, or two stage for a 16:1 ratio, up to 10,000 psig with flow rates of 14 scfu. The compressor design removes the danger involved with a lubricated compressor in the event of failure of a purification system.

No. 469 on Reader Service Card

PERFORMS 36 TIMES LONGER AT 1,000°F THAN ANY OTHER LUBRICANT!

General Magnaplate's HI-T-LUBE* is a dry film lubricant that actually provides a lower coefficient of friction as pressure increases... and an almost constant coefficient of friction at temperatures ranging from —100° to +1,500°F. Its performance under high loads, at high temperatures, enabled G. E. to crack the supersonic thermal barrier under these conditions: temperatures to 1,000°F, applied load of 1,400 lbs. rotating at 720 rpm, reversing direction every 3 seconds... HI-T-LUBE* performed effectively for 3 hours where other lubricants failed in less than 5 minutes! Other tests proved its fast heat dissipation, adherence under all conditions, ruggedness and permanence. For all the facts, write today!

*Trade-Mark

GENERAL MAGNAPLATE CORPORATION
328 Main St., Belleville, N. J. • PL 1-1500

No. 102 on Reader Service Card

871A

Improved FEL-PRO C5-A "HI-TEMP" ANTI-SEIZE THREAD COMPOUND

delivers MORE dollar value at same LOW COST!

All These New Improvements—

NEW • Lower breaking and running torque
NEW • Non-settling, non-hardening, homogenized composition
NEW • Can be used in below freezing weather
NEW • Increased lubricating and sealing qualities
NEW • Prevents rust and corrosion

Now in tubes and cans

FREE TEST SAMPLE PROVES HOW!

You'll save countless man hours and avoid costly replacement of broken studs, bolts, etc., with the protective cushioning action provided by the colloidal copper composition of C5-A. Improved C5-A Lubricates and Seals for fast, easy application and removal. Gives same protective performance even after high-pressure, high-temperature use, up to 1800° F. Can be used on all metals and plastics.

- ✓ Ends seizing and galling even up to 1800° F.
- ✓ Reduces wrench torque
- ✓ Stops needless stud breakage
- ✓ Permits repeated re-use
- ✓ Speeds assembly and disassembly
- ✓ Prevents galling of stainless steel

TRY C5-A NOW . . .

You'll find it ideal for aircraft uses such as slip joints, manifold studs, turbo blowers, etc. *Write for your free test sample today!*

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Dept. 52, 7450 N. McCormick Blvd., Skokie, Illinois

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ON EVERY U. S. COMMERCIAL JET *

The Firm Hand of Confidence

Mother's firm grip gives this mite the confidence of a million-miler. Trust. Assurance. Proven experience. Of such is confidence born. For the very same reasons, you find Shafer Aircraft Bearings on linkages between control surfaces and actuators *on every U.S. commercial jet flying today.*

Shafer is the one anti-friction roller bearing design that for years has led the field because it provides *all* the advantages that assure firm, reliable control: automatic, integral self-alignment up to plus or minus 10° of misalignment...*natural* roller alignment that eliminates roller-end wear and race scuffing...re-lubrication without disassembly...and greater capacity for a given envelope dimension and weight than any other self-aligning, anti-friction bearing available today.

Evaluate for yourself the many advantages of this full line of standard and special bearings. The industry's most experienced group of aircraft bearing engineers stands ready to assist you in this important area of your design. For a preview, send today for your copy of Catalog 59120. CHAIN Belt Company, 4704 West Greenfield Avenue, Milwaukee 1, Wisconsin.

* SHAFER AIRCRAFT BEARINGS ON EVERY ONE

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CONVAIR 880
DOUGLAS DC8

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AIRCRAFT ROLLER BEARINGS

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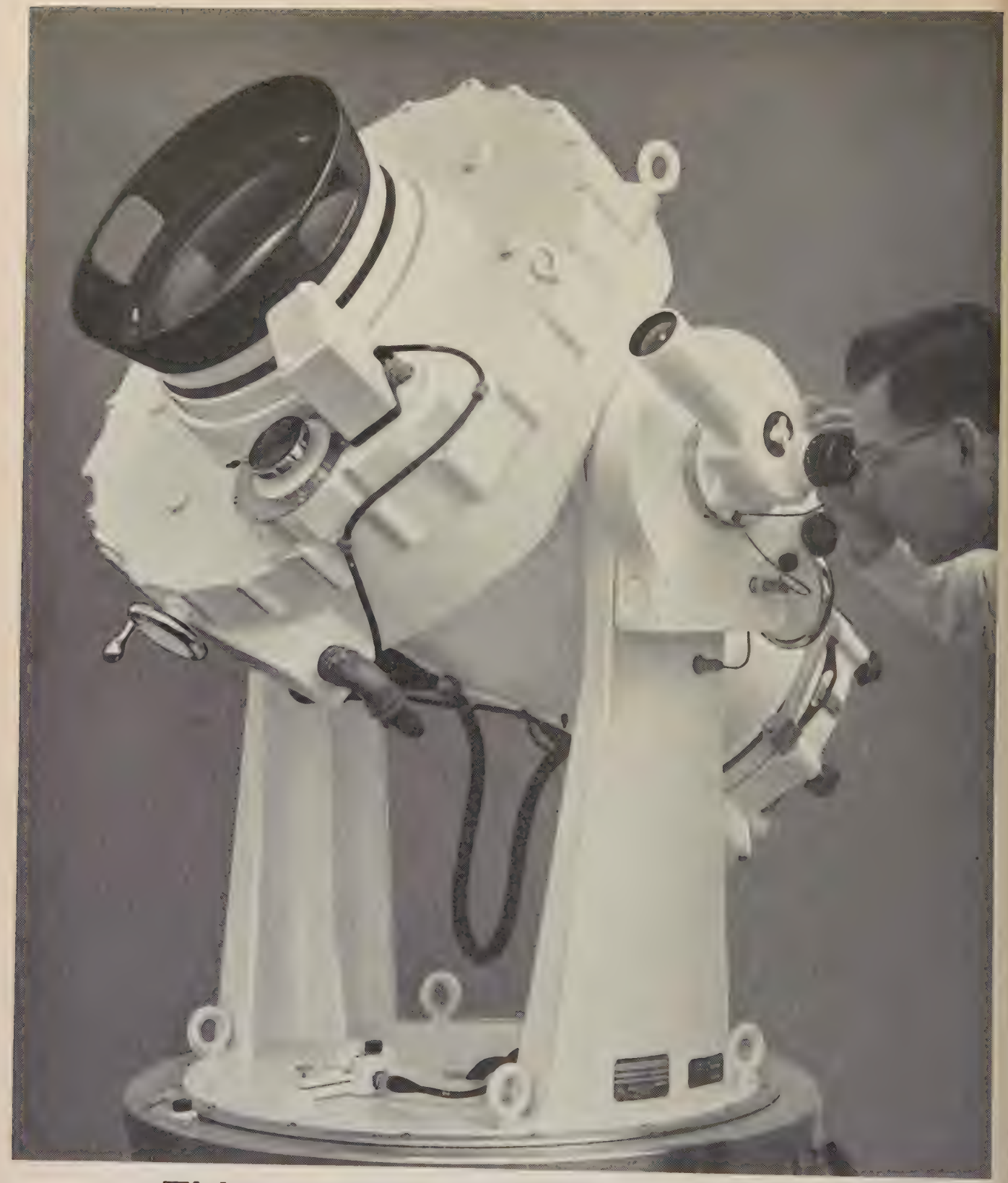


This camera watches the birdie

This is a ballistic camera, designed to photograph a missile in flight, and check its trajectory against a precise background of stars to detect the slightest deviation from course. It is the largest accurate ballistic camera ever built. Its 8-element, 600-mm, f/2 lens has an accuracy of 1 part in 200,000. Though the shutter is 12 inches in diameter, it opens and closes in 2 milliseconds. The entire instrument, including its unique lens and shutter, was designed and manufactured by Nortronics.

NORTRONICS
A DIVISION OF
NORTHROP

SINGLE AXIS ACCELEROMETER uses fluid damping

Fluid damping and torsion-bar spring restraint are used in a line of single axis accelerometers being produced by **Kearfott Div., General Precision, Inc., Dept. S/A, 1150 McBride Ave., Little Falls, N.J.** The units are said to feature high accuracy, large electrical output, and low null shift with temperature change.

In operation, the torsion bar and pivot and jewel assembly support a pickoff rotor and damping drum concentric to a multipole E bridge stator. The pickoff has low null voltage and a reference winding is used as feedback to the control amplifier to furnish the excitation so that the scale factor is maintained constant. Damping is achieved by viscous shearing of a silicone fluid.

No. 470 on Reader Service Card

INTEGRATING GYRO eliminates noise

Floated rate integrating gyros which feature angular momentums of 500,000 gm cm^2/sec, are now in production at **Kearfott Div., General Precision, Inc., Dept S/A, 1150 McBride Ave., Little Falls, N.J.** The gyros feature tight gimbal control and a low-impedance pickoff and DC torquer which virtually eliminates noise problems, says Kearfott.

Characteristics include mass unbalance of 0.2 deg/hr, fixed torque of 0.2 deg/hr, maximum torquing rate of 22,000 deg/hr, vibration of 30 g at 55-2000 cycles, shock of 60 g for 11 millisecond duration, and an operating life of 3000 hours.

No. 471 on Reader Service Card

HORIZON SENSORS detect thermal changes

The series 13-160 horizon sensors, available from **Barnes Eng. Co., Dept. S/A, 30 Commerce Rd., Stamford, Conn.**, are infrared scanning devices which detect sharp thermal discontinuity between the earth's atmosphere and outer space. Using germanium-immersed thermistor detectors, they are sensitive to far-infrared, while filtering out near-infrared radiation.

Manufactured in two models, one model includes three sensor heads and an electronic unit which provides power and processes signals. The second model has four heads and an associated electronic unit. Both models will establish a local vertical to within 0.1 degree.

No. 472 on Reader Service Card

FLYING COVER

From a distant ASW destroyer flies DASH* —an unmanned helicopter, observed from the ship by radar. Its mission—to deliver its weapon against an enemy submarine. Drone master control from the destroyer controls 'copter direction, altitude and weapon release. The shipboard and airborne radio control link is a product from Babcock, the world's leading designer and manufacturer of remote control and guidance systems.

BABCOCK—a rewarding environment for interesting Electronic Engineers.

*Drone Anti-Submarine Helicopter.

BABCOCK
ELECTRONICS CORPORATION
1640 Monrovia Avenue, Costa Mesa, California

No. 105 on Reader Service Card

"Big Fellow"
BELLOWS

Custom-Made
by Robertshaw...
up to 6 Ft. in Diameter

In nose cones, missiles, industrial applications, you can now specify the strength and flexibility of metal bellows in sizes up to six feet in diameter . . . and in any desired length. *You* specify . . . *we'll* deliver!

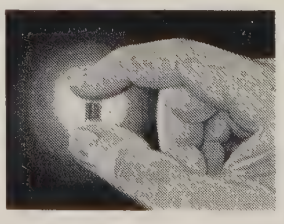
Custom-made in single, 2-ply or 3-ply thickness — with each ply up to .060" in thickness — these new Big-Fellow bellows broaden your design scope to make possible new concepts in large-size flexible connections under extreme conditions of heat, cold or pressure.

These huge bellows can be supplied in monel, brass, bronze, stainless steel, inconel or other materials, depending on properties and characteristics desired for your particular purpose.

How about smallness?

Our size range is equally complete in that direction, too . . . with bellows down to ¼" in diameter.

Free catalog with essential information on bellows design and characteristics. Ask for Catalog RA-R.



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MR CONTROLS
Robertshaw-Fulton Controls Company
FULTON SYLPHON DIVISION • KNOXVILLE 1, TENNESSEE

PITOT STATIC TESTOR for unitized checkout

One-man, one-unit checkout and calibration of all pressure and vacuum equipment on high performance aircraft is now possible with a pitot-static tester developed by **Burton Mfg. Co., Dept. S/A, 2520 Colorado Ave., Santa Monica, Calif.** This portable unit can be used in pre-flight and maintenance applications.

Reportedly, it can reproduce in-flight conditions as follows: altitude, 1000 to 80,000 ft; airspeed, 0 to 850 knots; Mach number, 0.5 to 2.2. The tester is designed for 115 V, 60 or 400 cps use. It includes a compressor, pump, valves and regulators, hose and electrical cables, all contained in a portable case.

No. 473 on Reader Service Card

ALARM PACKAGE for communication systems

Development of a microwave fault alarm system, providing immediate information on all monitored events, was announced recently by **Moore Associates, Inc., Dept. S/A, 893 American St., San Carlos, Calif.** The system features a continuous transmission of the status, regardless of alarm condition.

In operation, all contacts of the alarm sensing devices are scanned and a DC pulse code is generated. The output of the coder keys the tone transmitter which modulates the microwave baseband. Up to 22 repeater stations can be monitored over one three-kc voice channel. Decoded signals are displayed visually, and an audible annunciator sounds whenever a new alarm is detected.

No. 474 on Reader Service Card

DOPPLER NAVIGATOR has many uses

A Doppler navigation system, recently introduced by **Ryan Electronics, Dept. S/A, 5650 Kearny Mesa Rd., San Diego 12, Calif.,** is reported applicable to all types of aircraft, including VTOL and STOL. It is completely self-contained and provides automatic navigation and hovering, without radio aids, winds, or air speeds.

The system accommodates speeds from −50 kts to 2000 kts, altitudes from 0 to 70,000 ft, drift velocities from 0 to 300 kts, ground track from 0 to 360 deg, and vertical velocities to 60,000 fpm. Velocity error is less than 0.5 per cent and navigational error is 0.7 per cent of the distance traveled.

No. 475 on Reader Service Card

No. 106 on Reader Service Card

BENDIX FUEL NOZZLES SOLVE IN-FLIGHT RE-START PROBLEMS

Mighty comforting to the jet pilot is the knowledge that his engines are equipped with Bendix® Fuel Nozzles. Should a flame-out occur in flight, these dependable nozzles help restart his engines instantly. Bendix Fuel Nozzles also are noted for their ability to provide faster *cold starts* on the ground. These superior performance qualities result from the wealth of Bendix experience in advanced design and precision manufacturing. Most engine builders specify Bendix Fuel Nozzles *by name*. Perhaps these top-choice nozzles will help you solve *your* problems. Write today for full details.

Bendix-Elmira
ECLIPSE MACHINE DIVISION
ELMIRA, N. Y.

THE Bendix CORPORATION

No. 107 on Reader Service Card

For details on equipment listed in this section, write in item number on Reader Service Card

CONTROL AND DISPLAY SYSTEM FOR PROJECT MERCURY

America's first manned orbital flight will require the utmost in precise control and coordination. Data will be fed to Cape Canaveral by telemetry from the Mercury capsule, by communication links from 18 world-wide data stations, and from the Goddard Space Flight Center's dual IBM 7090 computer installation.

General Dynamics/Electronics, Information Technology Div., San Diego, Calif., has designed, built, and installed the control and display system at Cape Canaveral for Project Mercury, in cooperation with Bell Telephone Labs. The tracking and ground instrumentation system is being provided by a team led by Western Electric and including Bell Telephone, Bendix, IBM, and Burns & Roe.

The operations director, who coordinates all activities, sits at the center of the 60x50-ft operations room, flanked by other operations officers.

The flight dynamics officer and the retrofire controller are located along the room's right wall, together with a display of four flight-data recorders. The first recorder plots the launch path as gamma (inertial flight path angle) vs velocity ratio, and the orbital path as altitude above spherical earth vs velocity. Recorder 2 plots launch path as cross-range deviation and altitude vs range, and orbital path as semi-major axis deviation and altitude vs ground elapsed time. Recorder 3 plots insertion velocity and longitudinal acceleration vs elapsed time, yaw error and insertion altitude vs time-to-go-to-sustainer-engine cutoff, orbit as earth fixed longitude of perigee, and eccentricity vs elapsed time. Recorder 4 plots a chart of the launch recovery area.

Voice communications link all members of the flight team, supporting instrumentation personnel, selected members of the vehicle launching team, and ten other Mercury stations around the world. Provision has also been made by Western Electric for voice communication between the astronaut and the control center when the capsule passes over the Cape.

On the front wall, an 8x26-ft

Transducer Combines Advantages of Strain-Gage and Potentiometer Types

A new pressure transducer with the best overall characteristics of both strain-gage and potentiometer types has been developed by Fairchild Controls Corp., Components Div., 225 Park Ave., Hicksville, N. Y.

The 3S-G transducer consists essentially of three modules in an anodized aluminum case 1⅛ in. in diameter by three inches long. These modules perform the functions of energy conversion, signal conditioning, and calibration.

Energy conversion is accomplished by a sensitive element made up of several microminiature piezoresistive semiconductor elements coupled to a resilient, high-alloy-steel, low-mass diaphragm. These elements form the conducting paths of a four-arm Wheatstone Bridge.

Applied pressures deflect the diaphragm, creating an unbalance in the bridge and producing a DC signal proportional to the deflection. The diaphragm is proportioned to fit the selected pressure range—from 0-100 psig to 0-10,000 psig full scale. Pressure ranges below 100 psig will be made available shortly.

Input to the transducer is from 10-25 V DC nominal, and it can take up to 30 V DC without damage.

A completely transistorized amplifier receives the differential signal generated in the sensing element and produces the output signal. The transducer transfer function is 25 per cent. Thus, a full-range change in pressure at 20 V DC results in a 5-V DC output signal.

The calibrator is essentially an internally contained shunt resistor. When it is keyed across one leg of the Wheatstone Bridge, the 3S-G produces an output signal equivalent to one-half full scale rating.

Because it obviates the need for an amplifier, and because of its linearity, hysteresis, and environmental characteristics, Fairchild claims that the 3S-G represents at least a ten-fold increase in the state of the transducer art. **56**

preview

world map displays orbital path of the capsule, together with the locations and communication and tracking ranges of the remote tracking stations. The status of equipment at each remote station is also indicated.

Along the top of the map are indicators for Greenwich Mean Time, orbit number, countdown (hold and proceed) ground elapsed time, and time to retrofire. At left and right, manually plotted trend charts show critical parameters of the flight. (see *Box*).

The data entry console, behind the display map, manually updates the metered displays on flight controllers' consoles whenever Cape Canaveral is not in direct contact with the capsule. Data will be received via teletype from the remote stations and entered on the meters from this console. During live telemetry receipt, these meters and those of the controllers will be connected directly to decoding equipment.

Other displays in the control room include closed circuit TV receivers in the ceiling and on the consoles of the capsule communicator and flight director to monitor pad activities and initial takeoff.

Should an emergency arise during launch, the capsule re-entry sequence can be commanded by the flight director, the flight dynamics officer, or the retro controller.

Trend Chart Data

- astronaut's heart rate, respiration rate, and body temperature
- manual control fuel remaining
- auto control fuel remaining
- DC volts
- watt-hours remaining
- remaining oxygen (normal and emergency)
- oxygen partial pressure
- CO_2 partial pressure
- remaining coolant
- cabin air temperature and pressure
- suit inlet air temperature and pressure

equipment in brief

TESTER for stress conditions

An instrument capable of testing small samples of materials—from hard glassy or metallic solids to soft gels—to determine behavior under conditions of physical stress has been announced by **Wisconsin Alumni Research Foundation, Dept. S/A, P.O. Box 2217, Madison 5, Wis.** It will be manufactured and distributed by **Chesapeake Instrument Corp., Shadyside, Md.**

The apparatus is described as an electromagnetic instrument which measures dynamic mechanical properties of materials. It is said to be capable of predetermining many of the properties which may influence the behavior of elastic, metal, plastic and other substances when exposed to vibration, shock, wear and various additional kinds of stress.

Write in No. 252 on Reader Service Card

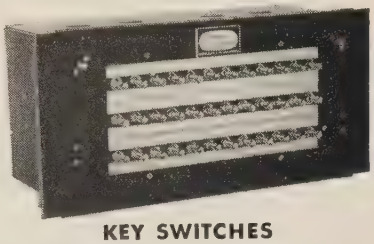
NEW Thermocouple Selector Switches

For fast, accurate indication of temperature from a number of thermocouples—to average readings from several measuring points—or to switch a thermocouple from one instrument to another—choose a new compact Thermo Electric Selector Switch.

These switches are compatible with any thermocouple or resistance thermometer, and any measuring instrument. Steel cases are dust and moisture proof, and are easily mounted on panel, rack, wall, or table.

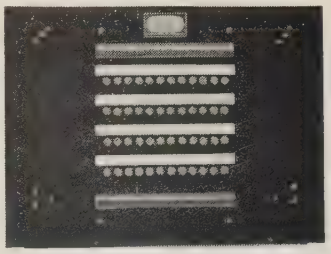
ROTARY SWITCHES

Capacities—OFF to 6, 12 or 24 measuring points. Available with binding post terminals or bunched leads for soldered connections.



KEY SWITCHES

Accommodate 1 to 144 sensing elements—locking or non-locking construction. Choose from several different cabinets.



PUSH BUTTON SWITCHES

OFF to 72 points—interlocking construction so that one switch remains "on" until another is actuated.

Write today for catalog 24-2-2

Thermo Electric CO., INC.

SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

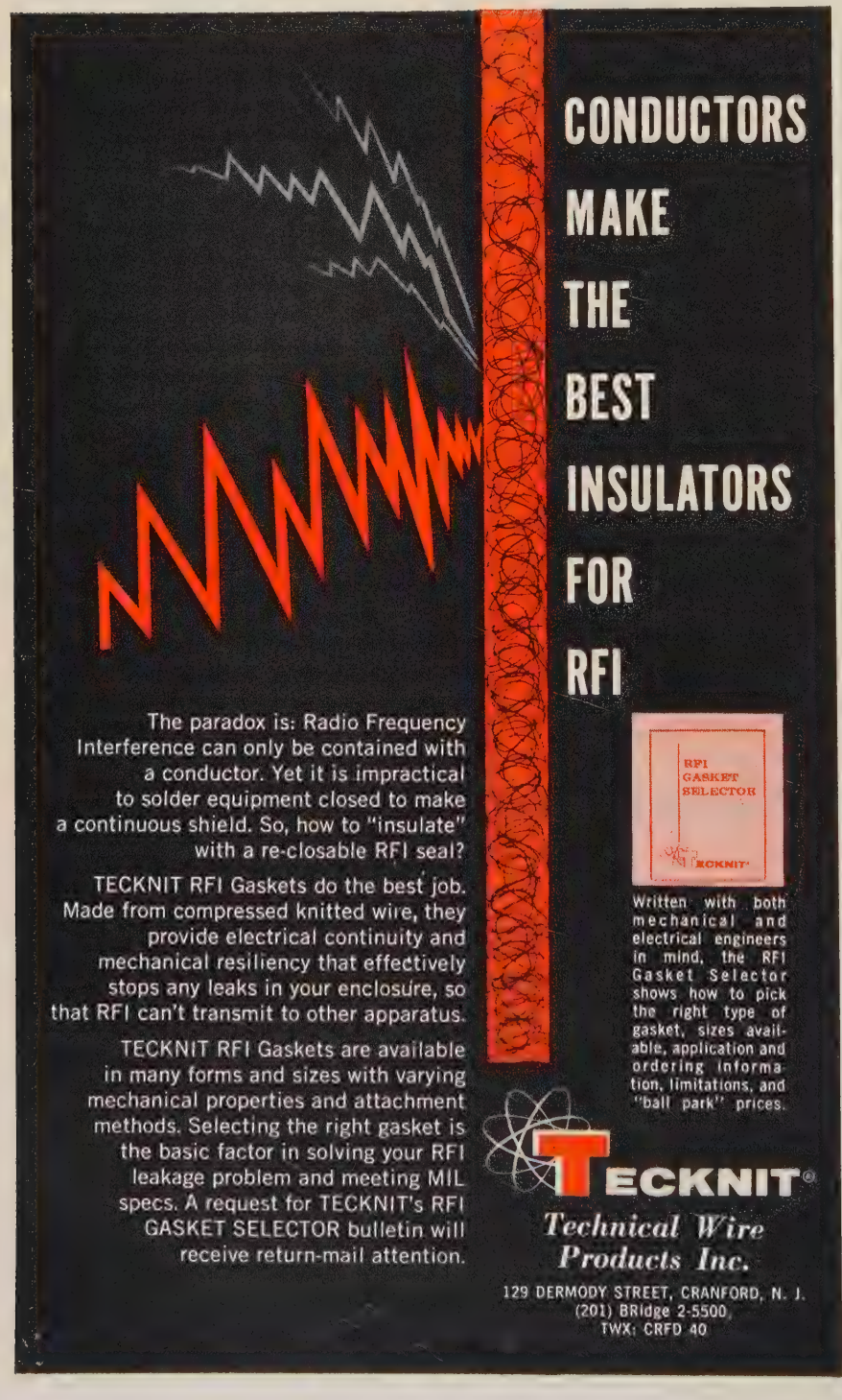
No. 108 on Reader Service Card

VIBRATION TABLES for reliability testing

A new line of vibration tables from **L. A. B. Corp., Dept. S/A, Skaneateles, N. Y.,** is said to offer lightweight construction and low cost.

Developed specifically for reliability testing of electronic equipment, the machines are available in two series —RH-5220 for horizontal vibration and RV-5340 for vertical vibration. The RH-5220 series can be equipped with either one or two tables. Units with standard components are operable in temperatures from —40 to 160 deg F. Maximum test load capacity of both series is 500 lb per table. The RV-5340 will produce 3.6 g, and the RH-5220, 3.2 g. Continuously indicating tachometers, timer controls for automatic stop-start operation are available. The tables are priced from approximately $4000 to $7000, depending on size and equipment.

No. 456 on Reader Service Card


CONDUCTORS MAKE THE BEST INSULATORS FOR RFI
The paradox is: Radio Frequency Interference can only be contained with a conductor. Yet it is impractical to solder equipment closed to make a continuous shield. So, how to "insulate" with a re-closable RFI seal?
TECKNIT RFI Gaskets do the best job. Made from compressed knitted wire, they provide electrical continuity and mechanical resiliency that effectively stops any leaks in your enclosure, so that RFI can't transmit to other apparatus.
TECKNIT RFI Gaskets are available in many forms and sizes with varying mechanical properties and attachment methods. Selecting the right gasket is the basic factor in solving your RFI leakage problem and meeting MIL specs. A request for TECKNIT's RFI GASKET SELECTOR bulletin will receive return-mail attention.
RFI GASKET SELECTOR
TECKNIT
Written with both mechanical and electrical engineers in mind, the RFI Gasket Selector shows how to pick the right type of gasket, sizes available, application and ordering information, limitations, and "ball park" prices.
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TWX: CRFD 40

TRANSDUCER has 1 to 200 psi range

A miniature potentiometer-type pressure transducer, available in ranges from 1 to 200 psi, gage or absolute, has been announced by **Princeton Machine & Development Co., Dept. S/A, 11 Washington Rd., Princeton Junction, N.J.**

An all-welded stainless steel case with an Inconel-X capsule is available to handle corrosive materials. Typical resolution of 0.25 to 0.33 percent is accomplished by means of a precision platinum alloy winding element. Linear or non-linear outputs are reported available with conformity of one per cent or better. Repeatability, hysteresis, and friction are typically under one-half percent.

No. 457 on Reader Service Card

COMPRESSION SYSTEM for maximum purity gases

A central compression system designed to meet the need for relatively high capacity short-time or continuous delivery of maximum purity air, helium, nitrogen, or other gases is offered by **Cardair Div., Marmon-Herrington Co., Inc., Dept. S/A, 307 N. Michigan Ave., Chicago, Ill.**

Developed and qualified as ICBM ground support equipment, the DPB-CCS system is reported to guarantee supply of gas at discharge pressure of 3500 to 12,000 psi continuous, with less than 1 ppm oil content and dewpoint of —100 deg F. Its capacity is 150 scfm at 128 psig intake; a four-stage, eight-cylinder compressor is standard. The complete system, a semi-portable skid design, includes dehydration and oil removal equipment and control panel. Maintenance is said to be minimal and simple.

No. 458 on Reader Service Card

HYDRAULIC POWER UNITS have variable capacity

A line of single pump hydraulic power units with a working capacity conversion feature is offered by **Hannifin Co., Dept. S/A, 501 S. Wolf Rd., Des Plaines, Ill.**

To meet possible increased power requirements after purchase, 11 of 13 Hannifin VSP units can be converted from 1000 to 2000 psi capacity by installing a motor of additional horsepower. All 13 models are offered with reservoir capacities from 15 to 60 gal and pump capacities to 35 gpm. All standard units are equipped with a separate relief valve and have an 1800 rpm motor.

No. 459 on Reader Service Card

No. 109 on Reader Service Card

IMPULSE BOMB
for propellant testing

The Model 601 impulse bomb has been added by **Technoproducts, Inc., Dept. S/A, P.O. Box 5293, Hamden, Conn.**, to its line of standardized test equipment for rocket propellants.

It provides the first commercially available tool for direct laboratory determination of propellant performance, according to the manufacturer. It has a nominal impulse volume of 5 cu in., and is rated for a maximum working pressure of 30,000 psi. It was developed primarily for testing high energy solid propellants and liquid monopropellants. The Model 601 is supplied complete with pressure transducer and firing circuit, requiring only a suitable recording system to receive the output of the transducer.

No. 460 on Reader Service Card

QUICK COUPLING
for lox and nitrogen

Development of a quick-disconnect coupling for use with liquid oxygen and nitrogen has been announced by **Cyrogenics, Inc., Dept. S/A, Stafford, Va.**

The device is ruggedized for missile and ground handling. Oxygen and nitrogen couplings are keyed differently to eliminate the possibility of erroneous connection. The coupling is manufactured from standard hex stock, so that no special tools are required for assembly, the manufacturer reports.

No. 461 on Reader Service Card

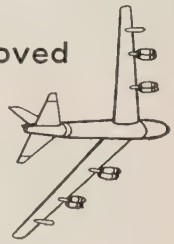
CONSOLES
for ultrasonic cleaning

Console type ultrasonic cleaners, housed in steel cabinets with stainless steel tops, are available from **National Ultrasonic Corp., Dept. S/A, 111 Montgomery Ave., Irvington 11, N. J.**

Finished in solvent resistant plextone green, the consoles are designed for laboratory and "clean room" installation. They are available with one, two, and three chambers, with all controls mounted on the sloping front panel. In the two-chamber console, designed primarily for use with solvents, the right hand chamber is used for cleaning and the left for a spray rinse. The third chamber of the three-chamber unit, designed for water base cleaners, contains a forced air heater to dry the cleaned parts. Six sizes, from 2 to 13 gal, are available.

No. 462 on Reader Service Card

It's the KLIXON® 6752-12
designed, produced and flight-approved
for the Boeing B-52H



The new KLIXON 6752-12 . . . approved in all ratings . . . is in a class by itself. It's so much better than previous aircraft circuit breakers that new Mil Specs are being written to cover its higher performance standards. Its superiority comes from a unique combination of advantages.

High rupture capacity: 6,000 amp 120 V-ac 400 cps; 4,200 amp 205 V-ac 400 cps; 6,000 amp 30 V-dc.

Ambient temperature compensation maintains protective capabilities from −65°F to +250°F.

Coordinated ratings remove low current circuits from line in case of fault, while keeping higher current circuits in operation.

Longer operating life: 20,000 guaranteed cycles, more than double the life expectancy of the standard MS25017 Circuit Breaker.

For complete data on the reliability-proved KLIXON 6752-12 Circuit Breaker . . . in 2½, 5, 7½, 10, 15, 20, 25, 35 and 50 amp ratings . . . write for literature today.

METALS & CONTROLS INC.
3709 FOREST ST. • ATTLEBORO, MASS
A CORPORATE DIVISION OF
TEXAS INSTRUMENTS
INCORPORATED

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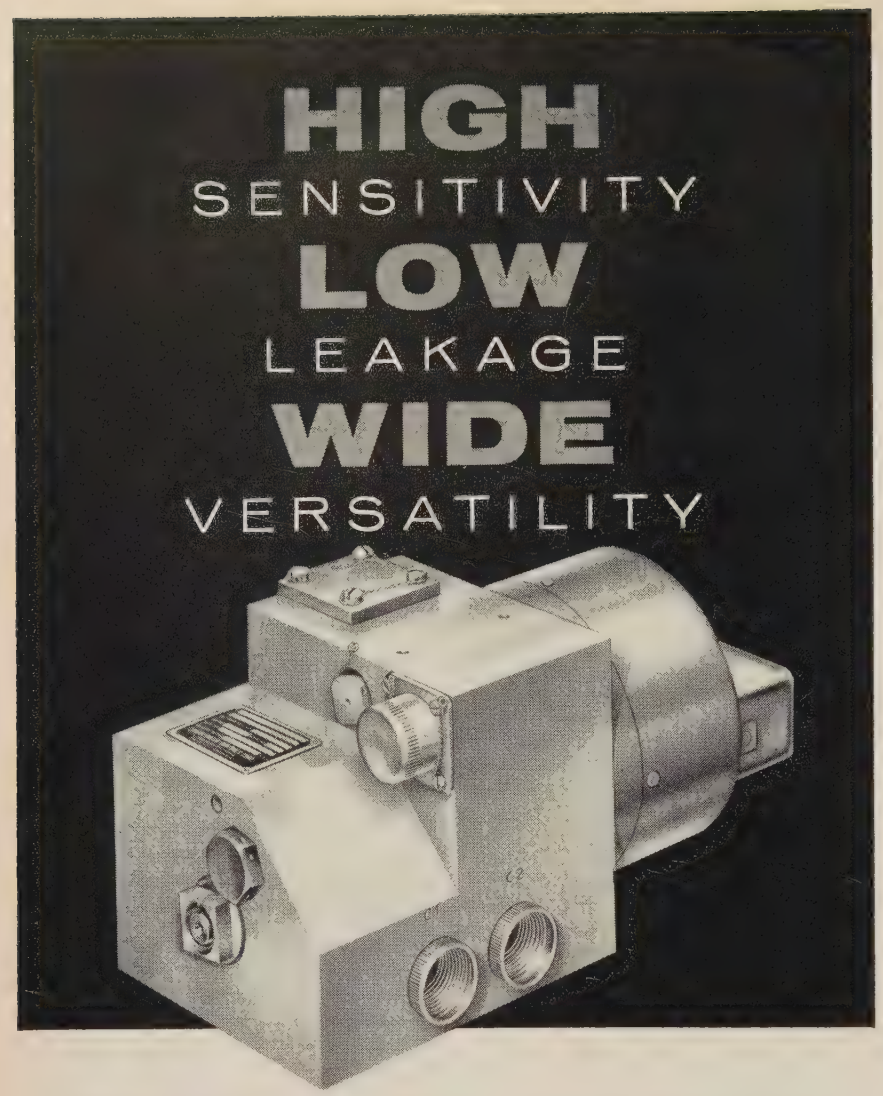


New electro-hydraulic flow control servo valve for industrial, aircraft and missile ground systems

This new line of electro-hydraulic servo valves combines wide versatility with exceptional performance factors for industrial as well as aircraft and missile ground systems.

It features high sensitivity and low leakage. The highly-sensitive spool-type pilot stage valve provides control with input signal power as low as two milliwatts. Application of dither to pilot stage reduces threshold level for use in the most exact systems. Mechanical feedback system balances hydraulic controlling mechanism at position indicated by input signal.

The versatility of this valve permits easy modification for output flows from 1 to 20 gpm at 1000 psi pressure drop. Special models available with flow ratings up to 50 gpm. Rated for system pressures up to 3000 psi, the valve will function with pressures as low as 500 psi with only loss in dynamic response. For complete application information, write or telephone Mr. Lee Wixsom, 750 South Isis Avenue, Inglewood, Calif., Phone — ORchard 1-7589, DDD Code 213.

PERFORMANCE FEATURES OF TYPE 141VN8 SERVO VALVES

Pressure rating: 3000 psi operating, 4500 psi proff, 7500 psi burst
Port Connections: AND10050
Internal leakage at null: 25 cu. in./min. max.
Output flow: shaped or linear
Rated flows: to 20 gpm at 1000 psi drop
Ambient and media temperature limits: —65 F to 275 F and higher

CONSOLIDATED CONTROLS CORPORATION

A Member of The Condec Group

BETHEL, CONNECTICUT
INGLEWOOD, CALIFORNIA

TRANSISTOR TESTER for 20 parameters

This automatic specification tester, Vast I, is capable of 20-parameter go-no-go testing of 3600 transistors per hour. Test set-up uses a 2000-bit program card, according to **Philco Corp., Lansdale Div., Dept. S/A, Lansdale, Pa.** Information recorded on the program card is assimilated by card-reader circuits and transposed into circuit adjustments.

The equipment accommodates three operators. Transistors are inserted in single unit sockets affixed to a conveyor system and transported sequentially from station to station.

No. 463 on Reader Service Card

COOLING UNIT for electronic equipment

A cooling unit for electronic equipment is manufactured by **Eastern Industries, Inc., Dept. S/A, 100 Skiff St., Hamden, Conn.** It will be used in the ground support system for Minuteman, the manufacturer reports.

Based on the refrigeration cooling principle, the equipment has a rating of 3340W at 125 deg F condenser temperature and 40 deg F evaporator temperature. It operates from 60 to 100 deg F and from sea level to 10,000 ft. Its power requirement is 120 V, single phase, 60 cycle and 208 V, 3 phase, 60 cycle. Designated RS 100-101 A, the cooling unit is said to be designed for complete reliability over extended time periods.

No. 464 on Reader Service Card

TEST CHAMBER has five temperature baths

A new Cloud and Pour test chamber from **Conrad, Inc., Dept. S/A, 141 Jefferson St., Holland, Mich,** has five individually thermostatically controlled temperature baths.

Temperature ranges of the five baths are —90 deg F, —60 deg F, —40 deg F, —20 deg F, and 20 deg F. Each bath can be adjusted approximately 20 deg from these nominal operating points. The unit is self contained with a Freon 13 and Freon 22 cascade refrigeration system. It is particularly designed for pour point and viscosity testing of oil to ASTM requirements, and is applicable to many electronics testing applications.

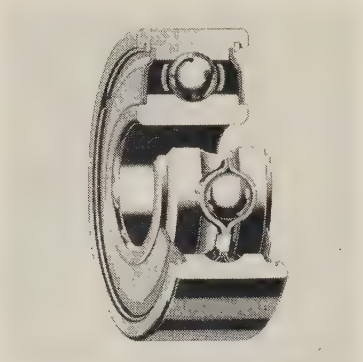
No. 465 on Reader Service Card

No. 111 on Reader Service Card

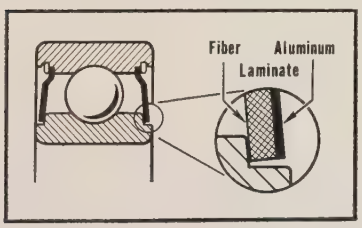
A NEW PRODUCT DEVELOPMENT FROM BARDEN

TO KEEP YOUR BRAINCHILD SPANKING CLEAN

A spaceman's helmet can keep a boy's face clean for a while, but the protection is far from permanent. A new Barden development, however—Flexeal—positively seals precision bearings against dirt while retaining needed lubricant, thus greatly increasing the reliability of high-speed motors, generators, computer memory drums and other equipment.



Sectional views of Flexeal precision bearing show how fiber-aluminum laminate seals against ground surface of inner ring to effectively block out dirt and retain bearing lubricant.



SEALED PRECISION BEARINGS

Barden's new Flexeal meets the demand for a low-friction seal that can stand up at high speeds in contaminated environments. Flexeal bearings are precision bearings with a seal of fiber-aluminum laminate that fits smoothly against a ground surface on the inner ring. The design effectively seals in lubricant, seals out contaminants and prevents airflow through the bearing. Friction is negligible and the bearing may be run up to the life limit imposed by the lubricant.

TEST RESULTS

Barden Flexeal bearings have been operated up to 3,000 hours at 80,000 rpm in portable grinders. Flexeal stands up under lineal speeds of 6,000 feet per minute, as against 2,000 to 3,000 fpm limits of most other rubbing seals. Operating temperatures range up to 300°F.

AVAILABLE NOW

Flexeal bearings are now available in ten unflanged and four flanged sizes from .3125" to 1.8504" O.D. For further data, ask for Flexeal Data Sheet F-1.

Barden is a major producer of precision ball bearings for instruments, weapon systems, computers and other high quality equipment.

for reliability...specify

BARDEN PRECISION BALL BEARINGS

THE BARDEN CORPORATION, 220 Park Ave., Danbury, Conn. Pioneer 3-9201
Western Office: 3850 Wilshire Blvd., Los Angeles 5, Calif. DUnkirk 5-0034

No. 112 on Reader Service Card

GRAPHITAR®

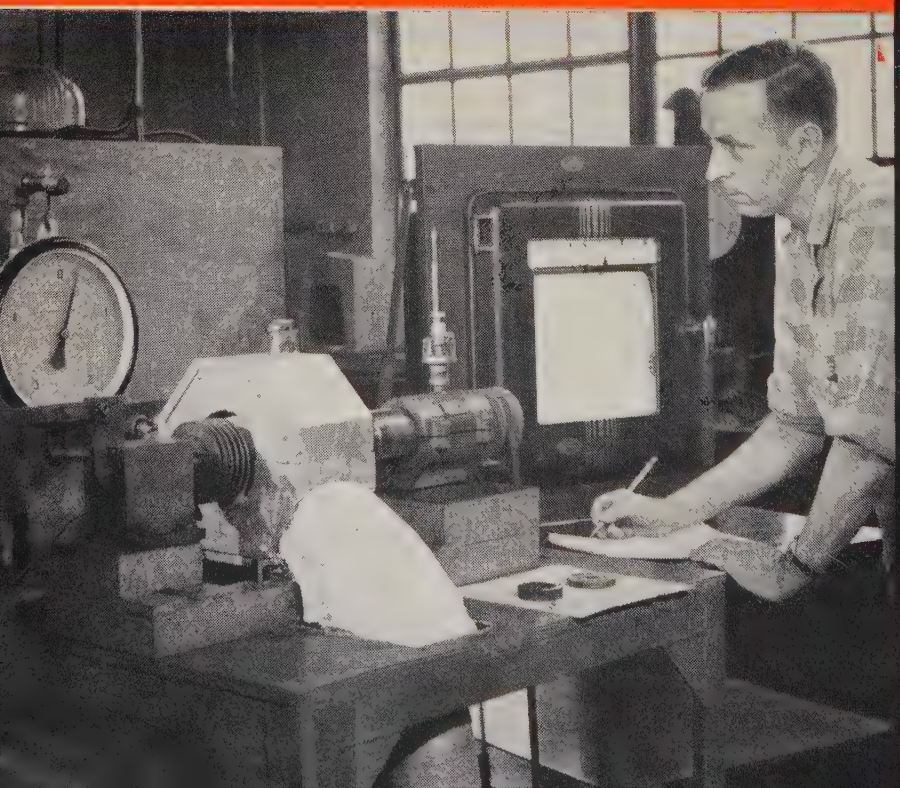
(CARBON-GRAPHITE)

FOR DEPENDABILITY

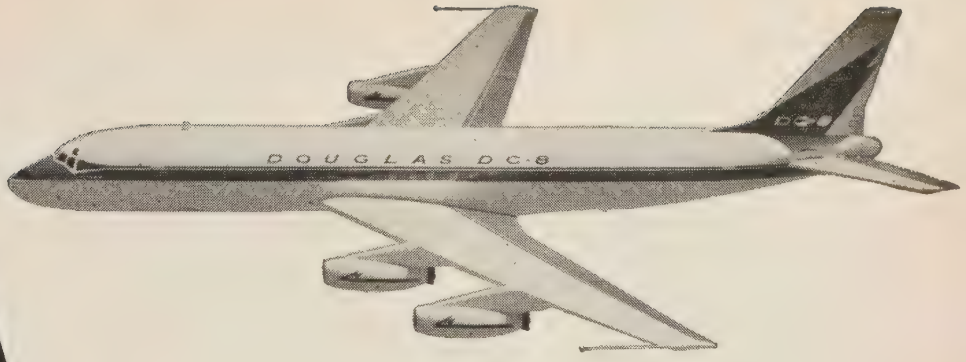
GRAPHITAR'S own character makes it dependable. A non-metallic engineering material, formed from carbon and graphite powders and a special binder, compacted under high pressures and furnaced at temperatures up to 4,500°F., GRAPHITAR possesses inherent characteristics that give finished parts exceptional dependability. GRAPHITAR'S natural heat resistance, for example, gives bearings, seals, vanes and rings exceptional dependability whenever dependability is one of the prime requisites.

There are other characteristics every bit as important to GRAPHITAR'S dependability. They include chemical and magnetic inertness, mechanical strength and adaptability to self-lubrication. Besides these natural characteristics, GRAPHITAR engineers can control porosity, strength and hardness to match GRAPHITAR'S physical properties to each individual application. It's little wonder that GRAPHITAR has become one of the design engineer's most versatile and useful materials.

In this laboratory test stand, oxidation-resistant GRAPHITAR parts are being checked under simulated operating conditions. Similar tests have proven that, when GRAPHITAR parts are exposed in oxidizing atmospheres at 1,200°F., they show only a weight loss of less than six percent after 200 hours.

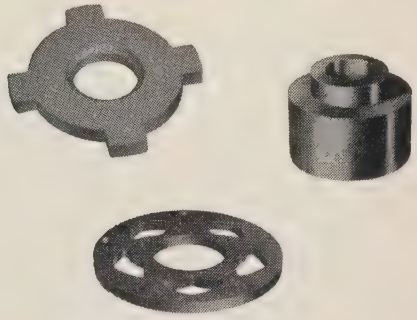


With the aid of photomicrographs, engineers at The United States Graphite Company gain valuable information about the microstructure of GRAPHITAR parts. Modern laboratory equipment such as the Metallograph enables engineering personnel to advance product quality for maximum dependability. Extensive and continuing R&D work has always been an integral part of The United States Graphite Company's operations.



GRAPHITAR air/oil seals employed in today's high-speed turbojet engines have established an enviable record for operating dependability. Installed on the main shaft of the turbine, GRAPHITAR seals successfully withstand tremendous shaft speeds and generated heat.

PHITAR bearings in the power reactor pumps
nerican nuclear submarines have compiled an
nding record for dependability.



Unusually shaped parts of GRAPHITAR can be molded easily with today's modern techniques. Ears, face slots and outside diameter notches of friction disc above, left, were molded in one operation without need for secondary machining and finishing.

ou have an application in which GRAPHITAR'S dependability can help
a tough problem, reduce your costs and improve the operational life of
products? Our engineering staff can help you find out. Our field men can
give specialized, on-the-job consultation. Send for your free copy of
eering Bulletin #20. Included is helpful information about the properties,
cteristics and applications of GRAPHITAR.

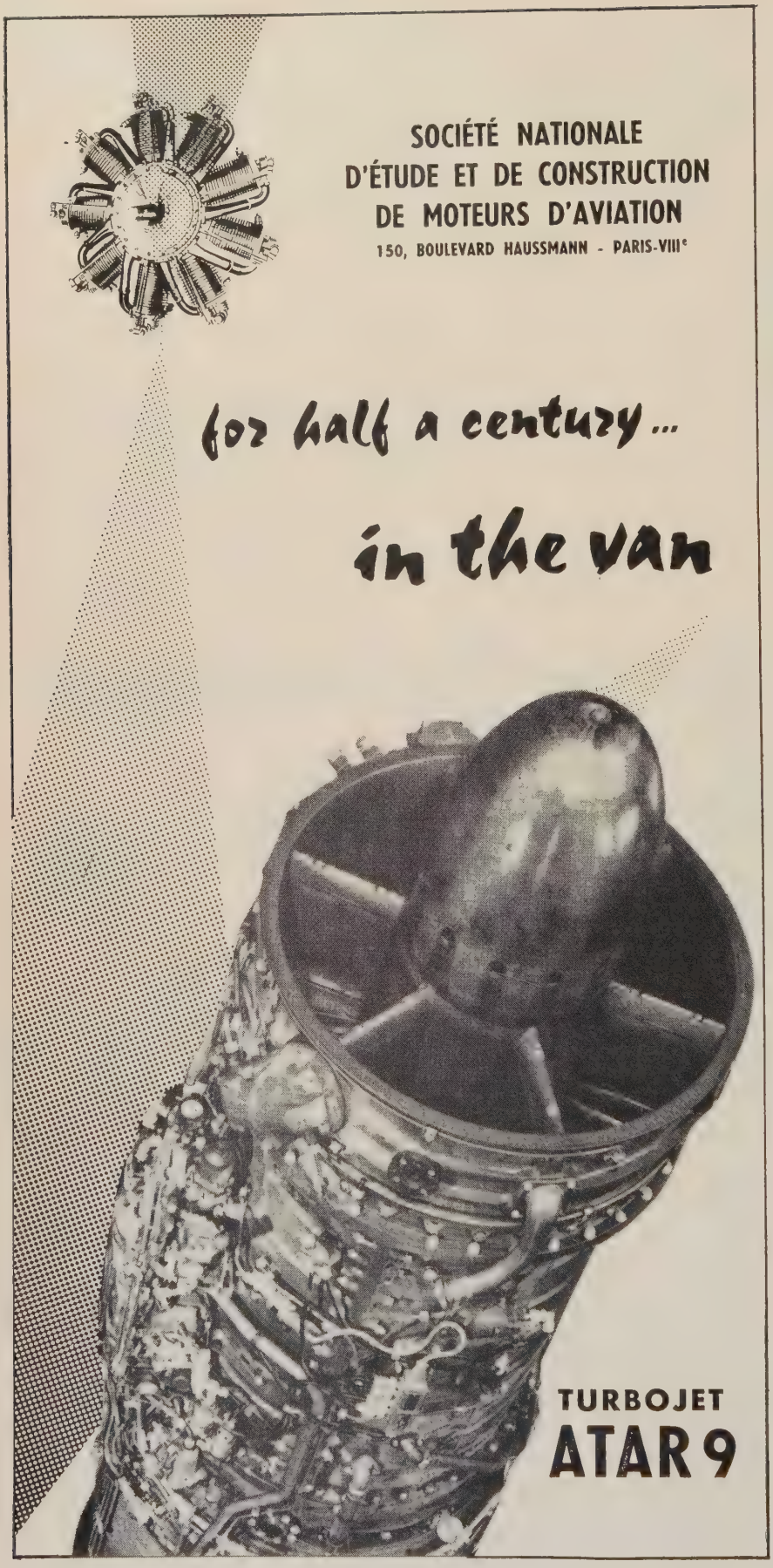
HE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 13, MICHIGAN

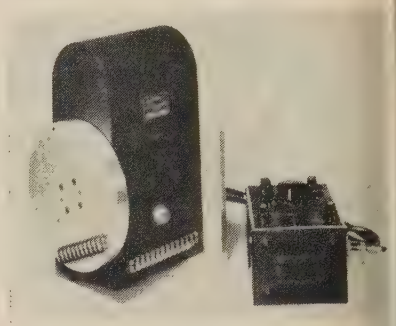
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

No. 113 on Reader Service Card

R-294-2



TEST FIXTURE checks gyros



A frequency response test fixture, Model FRO1, has been developed by **Humphrey, Inc., Dept. S/A, 2805 Cannon St., San Diego 6, Calif.** The device provides dynamic tests for rate gyros, integrating gyros, and accelerometers.

It consists of a variable-speed turntable built on a precision right-angle base. Slip rings provide connection from the base to table. Speed range is from 1 to 25 cps. Mounting surfaces parallel and perpendicular to the axis of rotation allow for testing rate gyros and angular accelerometers on a rate table, as well as linear accelerometers on a centrifuge.

No. 466 on Reader Service Card

MATERIALS EVALUATOR for thermal systems

This system is a standardized, calibrated high-temperature materials-testing apparatus for operation in the 30-200 kw power range. It produces 10,000 mph gas streams with stagnation pressures ranging from 1-20 atmospheres, says **Thermal Dynamics Corp., Dept. S/A, Lebanon, N. H.** It enables measurement of heat conduction and resistance in thermal shock and ablation environments.

The design accents consistent, reproducable results; the apparatus is calibrated against established standards.

No. 467 on Reader Service Card

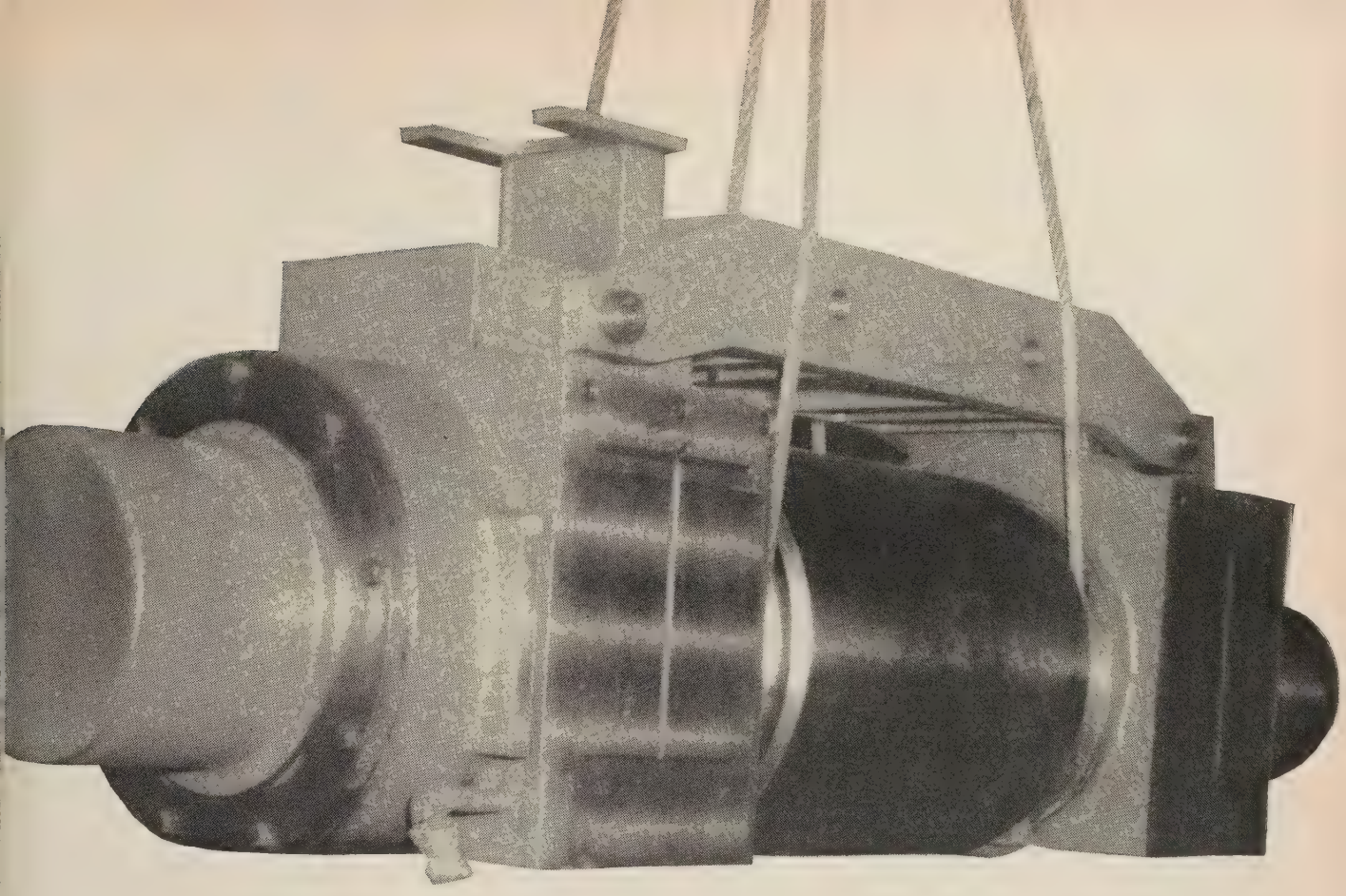
CYLINDER VALVES meet ICC regulation

The OV600 Series of aircraft oxygen cylinder valves for 1800-psi oxygen service, manufactured by **Robbins Aviation, Inc., Dept. S/A, 2350 E. 38th St., Los Angeles 58, Calif.**, is now available.

The valves have a burst disk, to meet ICC Tariff Regulation #10, which reduces allowable burst pressure of this safety disk from 3000 to 2775 psi at 160 deg F.

No. 468 on Reader Service Card

No. 114 on Reader Service Card



NOW GENERAL ELECTRIC CAN PRODUCE TUNGSTEN SHEET AND PLATE 2 FT. WIDE

At last you will be able to get wide tungsten sheet and plate from a domestic source.

Beginning next month a giant hot mill, part of which is shown here, will roll out unalloyed tungsten in 24-inch widths and thicknesses from 0.150 to 0.500 inches. Installed in General Electric's new Refractory Metals Plant, this special mill is the first step in the program to produce quality two foot wide refractory metals—tungsten, molybdenum, columbium, tantalum—in thicknesses down to 0.010 inches.

Tungsten sheet and plate in thickness of 0.150 inches and over have important applications in the spinning and forming of missile hardware. And General Electric scientists and engineers have developed a completely new process for rolling it with just the right metallurgical structure for such applications.

This process gives you *reproducibility*. The tungsten sheet you order next year will be exactly like the sheet you order tomorrow.

But don't wait until tomorrow to find out more about new wide Tungsten sheet and plate! Contact: General Electric Co., Lamp Metals and Components Dept. SA-91, 21800 Tungsten Rd., Cleveland 17, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

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HOW TO GET THE POWER TRANSISTORS YOU NEED?

JUST ASK DELCO. For even though our catalog lists only a handful of germanium power transistors, there is only a handful out of all those ever catalogued that we don't make. And those only because nobody ever asked for them.

We've made, by the millions, both large and small power transistors. Both diamond and round base. Both industrial and military types. And each in a wide variety of parameters that have proved themselves reliable in nearly every conceivable application.

You get Delco transistors fast. You get Delco transistors in any quantity. And for all their high reliability, you get them reasonably priced. All you have to do is contact our nearest sales office—and ask for them.

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TRinity 3-6560

DELCO RADIO

Division of
General Motors
Kokomo, Indiana

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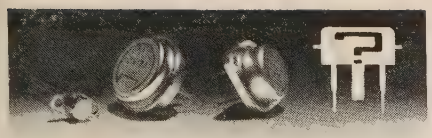

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DELCO RADIO

PACKAGED COMPRESSOR *is multi-stage unit*

This multi-stage, balanced/opposed, packaged compressor is suited for rupture-test and experimental work, shock-wave and acceleration-phenomena study, missile ground-support equipment, oxygen- and nitrogen-generating plans, high-pressure valve and regulator testing, and hydrocarbon gas compression, says **Clark Bros. Co., Dept. S/A, Olean, N. Y.**

The unit is water-cooled with capacities of up to 190 cfm. It is capable of compressing air or gas up to 10,000 psig. Two models are available, ICA-64 and ICA-66. Both models include the compressor, motor, intercoolers, moisture separators, relief valves, automatic unloaders, control panel, gauges and integral piping.

No. 256 on Reader Service Card

AUTOMATIC ANALYZER *checks up to 120 conductors*

Designed for automatic operation, this Model 8524 analyzer can test the insulation resistance and dielectric strength of cables containing up to 120 conductors. According to **Associated Research, Inc., Dept. S/A, 3777 W. Belmont Ave., Chicago 18, Ill.**, the analyzer is also self-checking.

A programed sequence can be set into the analyzer to test for continuity, high-voltage breakdown, and insulation resistance. Limits can be set from 0.5 to 200 ohms, for resistance. Hi-potting voltage, AC or DC, is adjustable from O-500 V, with minimum acceptable leakage current adjustable from 1 microamp to 2.5 milliamps DC or 0.5 milliamps to 3 amps AC. Minimum acceptable insulation resistance can be set from 1 to 50,000 megohms.

No. 257 on Reader Service Card

COOLING UNITS *modified for ground support*

This cooling unit was originally designed for cooling klystron amplifiers in the Eagle missile guidance system. The basic unit is being modified for use in ground support equipment, says **Lear-Romec Division of Lear, Inc., Dept. S/A, 3171 South Bundy Drive, Santa Monica, Calif.** The liquid-to-air cooling unit shown here has a nominal heat dissipation rate of 9375 W.

Other liquid-to-air heat transfer systems are also being developed for ground support equipment applications, says Lear. They will have cooling capacities of 100-10,000 watts with operating temperatures in the —65 to 250-deg-F range.

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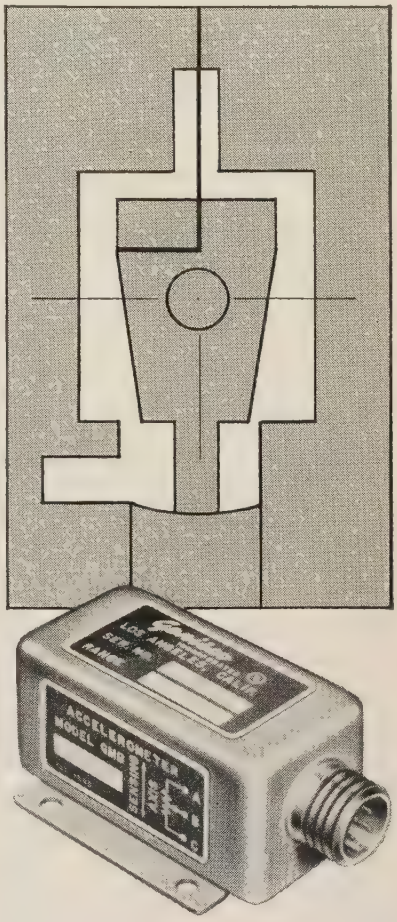
SELECTIVE
Gas-Damped
SENSITIVITY



GENISCO
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for airborne applications

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Genisco's GMB Series Accelerometers feature the advantages of gas damping which remains constant over wide temperature ranges for extreme accuracy and consistency. These units are ruggedly designed and constructed to operate reliably under conditions of high vibration and shock. The GMB Series Accelerometers are hermetically sealed units, available with either precision potentiometer pickoff or switch contacts... Standard or custom models.

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INCORPORATED
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No. 117 on Reader Service Card

STRAIN GAGE welds to aluminum

This weldable strain gage is designed for attachment to aluminum missile skins and can be attached to almost all aluminum alloys. Each gage will operate at temperatures equal to the deterioration point of aluminum, says **Microdot, Inc., Dept. S/A, 220 Pasadena Ave., S. Pasadena, Calif.** The gage can be attached with an 80 watt-second capacitor discharge welder.

The gages are 3/16 in. wide and either 1 5/32 in. or 9 3/16 in. long. Both 60 and 120 ohm gages are offered.

No. 259 on Reader Service Card

SERVO ANALYZER is all-electronic

This all-electronic servo analyzer, Model 900, provides direct reading phase and amplitude measurements vs frequency for electronic, electromechanical, or mechanical servo systems, according to **Remanco, Inc., Dept. S/A, 1805 Colorado, Santa Monica, Calif.** It is said to provide maximum stability.

The analyzer is available in three frequency models: 0.1-100 cps; 0.01 100 cps; and 0.001-100 cps, with sine-wave or square-wave modulated or unmodulated output.

No. 260 on Reader Service Card

RPI space age support provides . . .

PROPELLANT POWERED ACTUATORS

that develop more energy per pound per cubic inch than conventional actuators

Rocket Power Inc., has designed, tested, qualified and produced a wide range of precision propellant-power actuators for critical aircraft/missile applications. These versatile devices are used to —

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- *close*
- *push*
- *eject*
- *open*
- *position*
- *pull*

Rotary or linear, they provide high reliability and instant response.

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FOR TECHNICAL DATA on RPI propellant-powered actuators, write for Technical Bulletin #1100.

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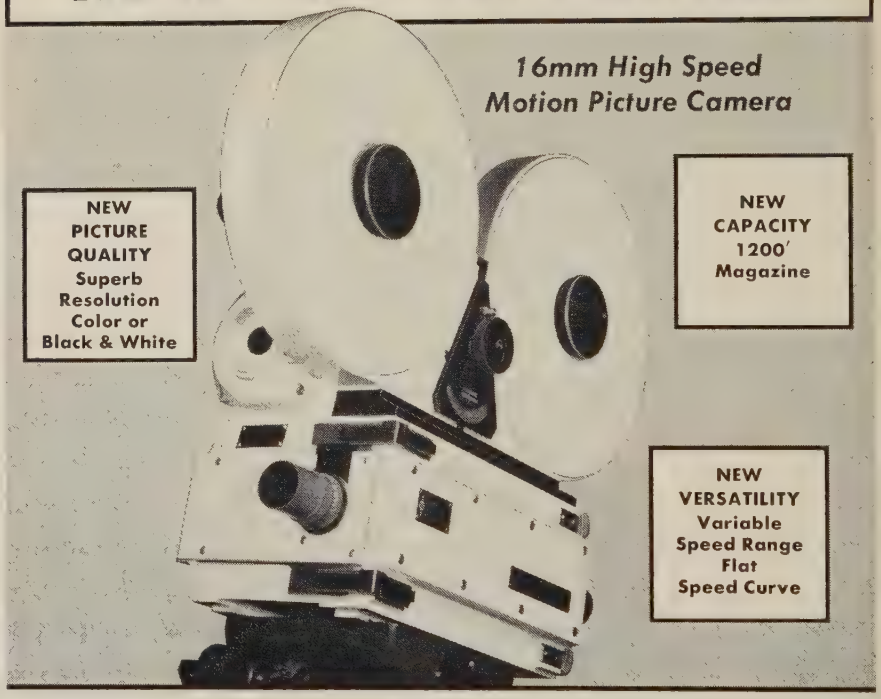
16mm High Speed Motion Picture Camera



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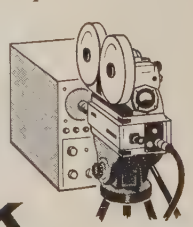
NEW CAPACITY 1200′ Magazine

NEW VERSATILITY Variable Speed Range Flat Speed Curve

Years Ahead in Design and Performance

A high speed camera with large film capacity . . . with a variety of speed ranges and high resolution has long been wanted by industry, the military and the government. The FASTAX WF-30 fills all these requirements and more. Darkroom loaded, "T" core, the magazine holds sufficient film for most studies. Camera versatility is another key feature. Variable speed range, controlled by a solid state loop servo device . . . rapid acceleration with flat speed curve within ±4% selected rate . . . start-stop capabilities. Superb resolution over entire frame results from excellent lens system and a sector shutter between rotating prism and focal plane.

WRITE for complete information and prices on WF-30 . . . the newest FASTAX in the wide line of Wollensak high speed motion picture cameras.



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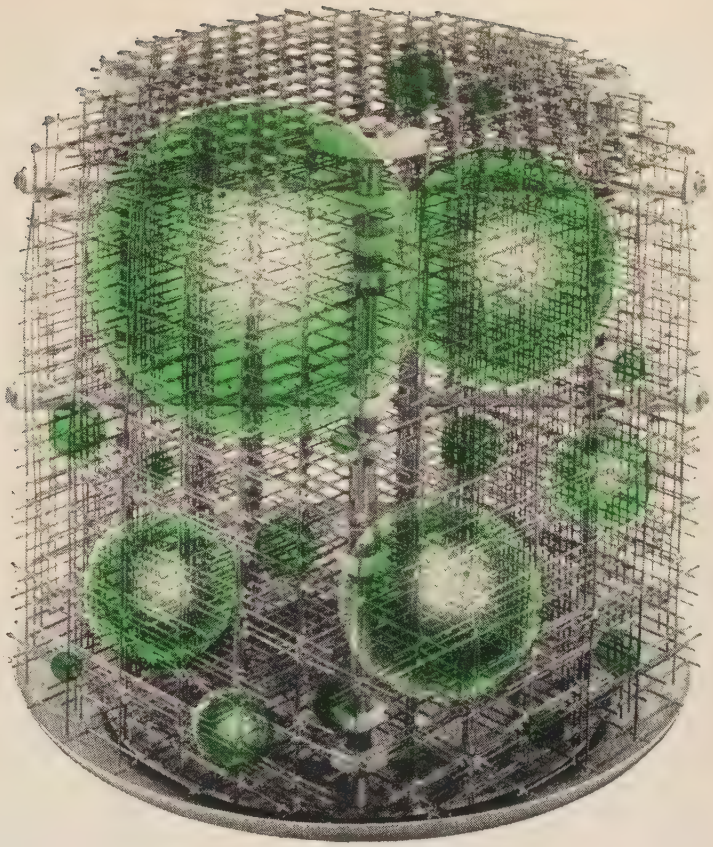
Another measure of the competence of Liquidometer in advanced instrumentation



FLUID, FOAM, OR FLOATING GLOBULES...

whatever a liquid's state or attitude, whether still or in agitation, the volume indication is the same with the Liquidometer Matrix Liquid Quantity Gauge. A capacitor type measuring probe — intercellular in construction — is the heart of the system. In addition to actuating an indicator, output can be telemetered, used for control purposes, or fed into computers. Potential applications: measuring liquid oxygen for astronauts; gauging liquids in advanced rocket propulsion systems; all-attitude gauging of aircraft fuels. Technical details in Booklet 694.

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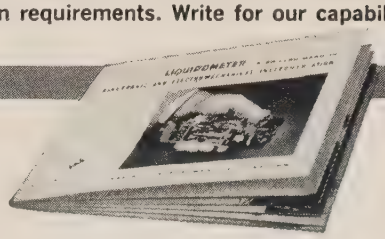

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An Example of
Synthane *You-shaped* Versatility

Do you have a materials problem? Perhaps laminated plastics is the answer: Why not discuss it with our field representative in your territory? He has behind him the entire Synthane organization with over 32 years of experience in the manufacture and fabrication of laminated plastics. Our engineers, technicians and field representatives are specialists in this field, and over two-thirds of our people have over 10 years' experience with Synthane. The solution to your materials problem can probably be found at Synthane.

You-shaped Versatility makes Synthane a Better Buy in Laminates

SYNTHANE CORPORATION OAKS, PENNA.

Synthane Corporation, 55 River Rd., Oaks, Pa.
Gentlemen:
Please send me information relating to Synthane as a source for laminated plastics materials and parts.

Name_____

Address_____

City_____ Zone____ State_____

DC PRESSURE TRANSDUCER for critical weight use

Their new P2-3000 series variable-reluctance DC pressure transducers are particularly suited to applications having critical weight limitation, according to **Daystrom-Wiancko Engineering Co., Dept. S/A, 255 No. Halstead St., Pasadena, Calif.** The type P2-3076 unit is reported available for pressures up to 5000 psig. This type weighs five oz and requires only 3 ma at 28 volts DC for 0- to 5-volt DC output.

Designs are characterized by a low output impedance of 1000 ohms and mutually isolated input, output, and ground circuits to minimize noise problems on long line. No amplifiers are used. Other features include excellent linearity, low hysteresis, continuous resolution, and immunity to temperature, acceleration, and vibration effects, says the manufacturer.

No. 300 on Reader Service Card

PNEUMATIC SHOCK TESTER has 3000 g impact

A pneumatic powered shock test machine for production test of small electronic components has been announced by the **Industrial Products Subdiv., Avco Research and Advanced Development Div., Dept. S/A, Wilmington, Mass.**

As reported, the machine is designed to meet the 3000 g and 0.2 millisecond shock pulse requirement of MIL-S-19500B. At an air pressure setting of 80 lb, a test drop height of 7 in. is equivalent to a 4-foot free fall drop. The tester can handle specimen loads of up to 30 lb and can generate an impact shock velocity of up to 192 in/sec.

No. 301 on Reader Service Card

SMALL CHAMBER serves all test environments

This 3-cu-ft chamber is for all environments, high and low temperatures, altitude and humidity. Temperatures from —100 deg F to +500 deg F, accurately controlled to ±2 per cent, provide a thermal capacity of 1200 BTu/hr at —100 deg F; pulldown is from ambient to —100 deg F in sixty minutes and warmup to +500 deg F in 60 minutes, says **Cincinnati Sub Zero Products, Dept. S/A, 3932 Reading Rd., Cincinnati 29, Ohio.** Altitude of 100,000 ft is attained in 30 minutes and 150,000 ft in sixty; humidity range is 20 to 95 per cent ±5 per cent at temperatures between +35 and +200 deg F.

The 18 in. × 18 in. × 18 in. chamber area is equipped with a recessed fin coil evaporator, adjustable shelves, pressurized amphenol fittings, and interior illumination.

No. 302 on Reader Service Card

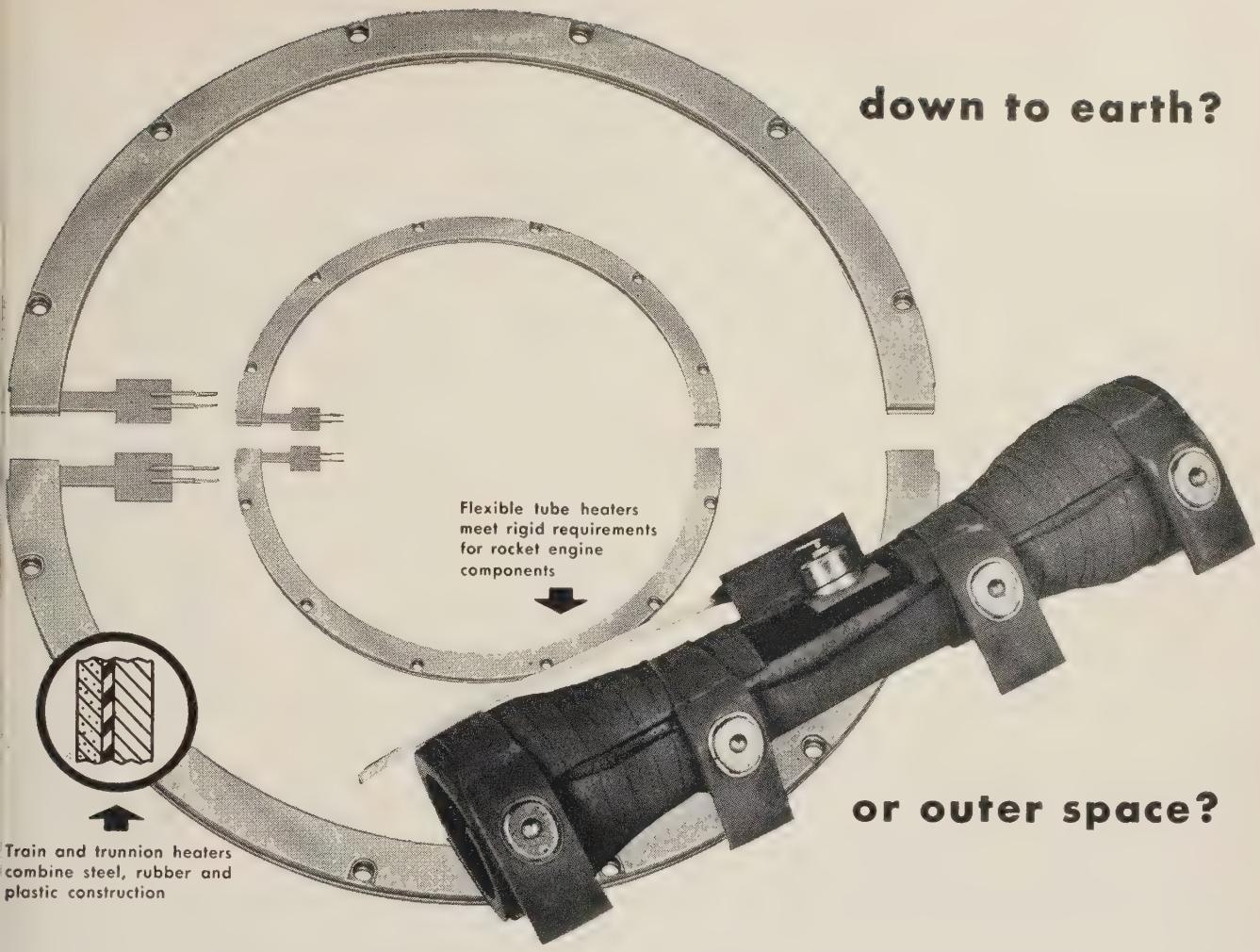
CRYOGENIC LIQUID SAMPLER aids quality control

A cryogenic liquid sampling device for use as an aid in missile LOX quality control has been designed by **Air Products, Inc., Dept. S/A, Allentown, Pa.** To obtain accurate samples of cryogenic liquids, the speciments must be taken from a completely closed system. Also, the liquid changes composition as it boils at —300 deg or colder. Accurate samples can only be obtained by capturing a measured all-liquid sample and converting it to gas in a closed system.

The sampler, which is reported to meet Air Force specification Mil-P-25508B, will sample and prepare any low boiling point liquid for analysis.

No. 303 on Reader Service Card

No. 121 on Reader Service Card


down to earth?
Flexible tube heaters meet rigid requirements for rocket engine components
Train and trunnion heaters combine steel, rubber and plastic construction
or outer space?

SAFEWAY Heat Elements apply engineering imagination to all defrosting, de-icing and heating problems

Unusual and intricate *cold-control* problems frequently find their way to us. The circular heat elements shown above are components of vital ground support equipment. Exacting specifications called for the "sandwiching" of a continuous, circular heating element between two rings of different materials. The actual heating element is encased in silicone rubber and then bonded under controlled heat and pressure to two external rings: one of *silicone-resin impregnated fiberglas* and the other of *stainless steel.* The completed unit must withstand lengthy soak-testing in a salt water solution. Outside diameters of the train and trunnion rings are 56 7/8" and 29 3/8", respectively.

The flexible tube heater illustrated is another successful solution to a complex flight propulsion system heating problem. In this instance, custom-made flexible tube heaters have resistance wire molded in silicone rubber. Result—uniformly *dependable* heat is provided for rocket engine components.

MEETS THE MOST SPECIALIZED REQUIREMENTS

Safeway's long-term military and industrial experience backs up the production of thoroughly reliable heating, de-frosting and de-icing units —*woven, molded* or *strung*—for scores of different applications. So, if *cold-control*—of any description—is on your "problem list", write or phone us. Chances are excellent we can help you.

Write today for our fact-filled brochure, describing the wide range of materials, specifications and application possibilities. Safeway engineers will gladly analyze your requirements and submit practical recommendations.

Safeway HEAT ELEMENTS INC.

Middlefield Street • Middletown, Connecticut

No. 122 on Reader Service Card

CP electric motors...ready to meet every

PROBLEM
of missile subcontractor

Obtain a motor to drive a missile hydraulic system constant displacement pump. It must:

1. Operate on dc current, voltage range 24-30 volts, and be designed for optional rotation
2. Develop 1.5 hp.
3. Be suitable for intermittent duty service
4. Withstand ambient temperatures from −65°F to +275°F
5. Meet MIL. Specs E-5272 and M-8609
6. Have explosion-proof enclosure
7. Be equipped with thermal protection (to operate external relay) and radio noise filter
8. Have minimum weight

SOLUTION
by Chicago Pneumatic

CP Design Engineers, drawing on their wide experience in deve oping special designs and types of motors, produced th CP-74FA Motor. It is ideally suited to meet these highly demand ing requirements.

If you are faced with a specialized problem involving su fractional, fractional or integral horsepower, lightweight moto or actuators for aircraft, missile, space craft, naval or milita applications write, outlining your requirements, to: **Chicag Pneumatic Tool Company, 8 East 44th Street, New York 17, N.**

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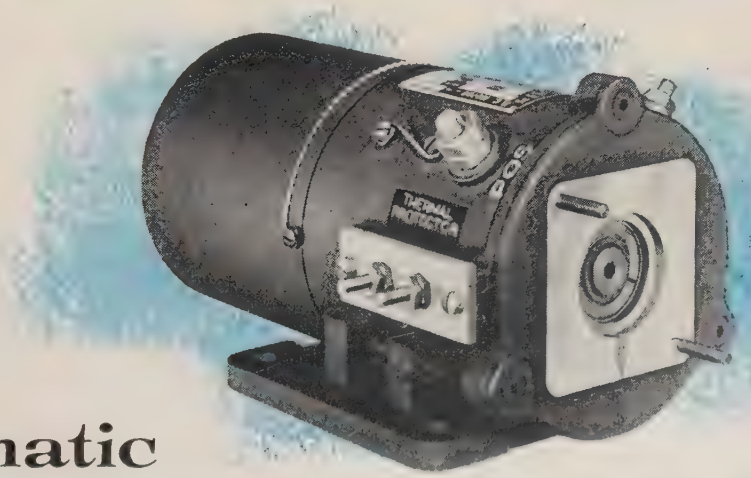
countdown" checkout, every "in flight" demand!

74FA Motor as furnished for driving constant
lacement pump on missile hydraulic system. Motor
be adapted for similar missile drives or other
rmittent duty applications with slight mechanical
nges. Weight 7.8 pounds.



Chicago Pneumatic

TION ACCESSORIES • PNEUMATIC TOOLS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS • VACUUM PUMPS

R/M CAPABILITY creates a new flame-barrier

To meet the stepped-up firewall requirements for some of America's "hottest" jets, R/M engineers were required to develop a barrier material which would resist flame-penetration up to 1800°F and operate at ambient temperatures as high as 500°F without appreciable absorption of fuels and solvents.* Furthermore, the material had to remain flexible even at temperatures as low as –40°F.

Because of R/M's exceptional capability in the packing field, the problem was tackled and solved to the customer's complete satisfaction.

The answer in this case was development of R/M-RL641—Viton† Inconel‡ wire-reinforced sheet. Viton's resistance to heat, chemicals, jet fuels and solvents—and at extreme temperatures—is in a range completely new in the elastomer field. Coated cloths, tadpole tape, channel tape, and other products put R/M capability to work.

Write for complete information and literature.

*Meeting FAA regulations.
† Viton is a DuPont trademark
‡ Inconel an International Nickel trademark

RAYBESTOS-MANHATTAN, INC.
RM PACKINGS
PACKING DIVISION, PASSAIC, N.J.
MECHANICAL PACKINGS AND GASKET MATERIALS

FORCE GAGE
uses three transducers

The Model 2106 force gage uses three force transducers in the same plane which accurately simulate point force loading, according to **Endevco Corp., Dept. S/A, 161 E. California Blvd., Pasadena, Calif.** The "flat" configuration "practically removes" concern about shear loads, it was said.

The entire top and bottom surfaces of the unit are used as load bearing members and this area results in a gage with stiffness of at least 2x10, lb/in. Frequency response is ±5 per cent, 2 cps to 1/5 resonance frequency with 1000 megohm load and 5 cps to 1/5 resonance frequency with 100 megohm load.

No. 304 on Reader Service Card

G-ACCELERATOR
for research application

This Model B931 g-accelerator features an "extremely precise" electronically speed-controlled centrifuge for R&D. Order of precision is indicated by a 0.001 per cent allowable drift from angular velocity of either the main rotating arm or the outboard table, according to **Genisco, Inc., Dept. S/A, 2233 Federal Ave., Los Angeles 64, Calif.** The instrument uses a crystal-controlled oscillator to determine overall setting accuracy.

The model provides any discrete operating channels up to 30 g. It may be set up to maintain a spatially stable platform for the test object or to create several discrete and very accurate sinusoidal or constant g-accelerations. Operating modes include fixed azimuth orientation.

No. 305 on Reader Service Card

PRECISION TEST SET
for radar range calibration

This portable test set, used for precision radar range calibration, has a marker accuracy of ±.02 per cent, says **Loral Electronics Corp., Dept. S/A, 825 Bronx River Rd., New York 72, N.Y.** Reportedly, it can provide calibrated marker pulses at fixed time intervals of 12.2, 122, and 1220 micro seconds, or ranges of 1, 10, and 100 nautical miles.

Design features include front panel adjustment of trigger and range marker pulses and waveforms, modular construction, and 75 ohms output impedance for both trigger and video. Power requirements are 70 W at 115 V 50-60 cps.

No. 306 on Reader Service Card

No. 124 on Reader Service Card

Check Inquiry Form on Page 153

The Making of History was not only His Privilege

. . . It was His Goal

If you are an advanced degree physicist, scientist or electronic management engineer who seeks to shape air and space vehicles to their unique environmental problems rather than stretch existing designs for marginal success, you are needed at McDonnell.

Write R. F. Kaletta, Professional Placement, McDonnell Aircraft, St. Louis 66, Missouri

GHO *experience includes*

ELECTRICAL or COMMUNICATIONS CONSTRUCTION *at*

Andrews AFB	Washington D.C.
Cape Canaveral	Daytona Beach, Fla.
Eglin AFB	Pensacola, Fla.
Eilsen AFB	Fairbanks, Alaska
Ellsworth AFB	Rapid City, South Dakota
Elmendorf AFB	Anchorage, Alaska
Goose AFB	Goose Bay, Labrador
Ladd AFB	Fairbanks, Alaska
Larson AFB	Moses Lake, Wash.
Lockbourne AFB	Columbus, Ohio
Loring AFB	Limestone, Maine
Lowry AFB	Denver, Colorado
National Aeronautical Space Administration	Sandusky, Ohio
Offutt AFB	Omaha, Nebraska
Plattsburg AFB	Plattsburg, New York
Sonderstrom AFB	Sanderstromfjord, Greenland
Thule AFB	Thule, Greenland
U.S. Spanish Air Bases	Madrid, Spain
Vandenberg AFB	Lompoc, California
Warren AFB	Cheyenne, Wyoming
Westover AFB	Springfield, Mass.

The experience and dependability of GHO personnel is important to the precise operational success of our missile and Air Force bases. Whatever the problem, if it involves electrical or communications installations, GHO can do it efficiently and on time.

All projects, regardless of size, are operated and supervised with GHO experience and capability.

VACUUM SIMULATOR for on-the-line testing

A line of low-cost vacuum simulators is available from **Prenco Manufacturing Co., Dept. S/A, 2604 W. 14 Mile Rd., Royal Oak, Mich.,** for functional inspection test applications.

The Series VA units are said to be suitable for testing any part whose operation is accomplished with or affected by vacuum. Any vacuum condition can be duplicated to permit functional complete-cycle testing of parts at both maximum and minimum operating limits, the manufacturer reports, and the self-contained, motor-driven equipment eliminates the need for actual engine operation during inspection or test. Standard units are available for applications requiring ½ to 60 cfm capacity, and larger capacity units may be ordered.

No. 307 on Reader Service Card

CHECKOUT SYSTEM tests radar controller

This checkout test equipment was developed to check the operational readiness of bomber and missile radar control systems. According to **Dynamics Corp. of America, Dept. S/A, Garden City, N.Y.,** its use will cut testing time from four days to less than one hour. It was developed specifically for the AN/MSQ-1A radar control system.

The checkout equipment consists of 150 basic sections and some 10,000 parts housed in 24 cabinets, plus four portable metering units. Faulty radar operation during dynamic testing is pin-pointed by buzzers and flashing lights.

No. 308 on Reader Service Card

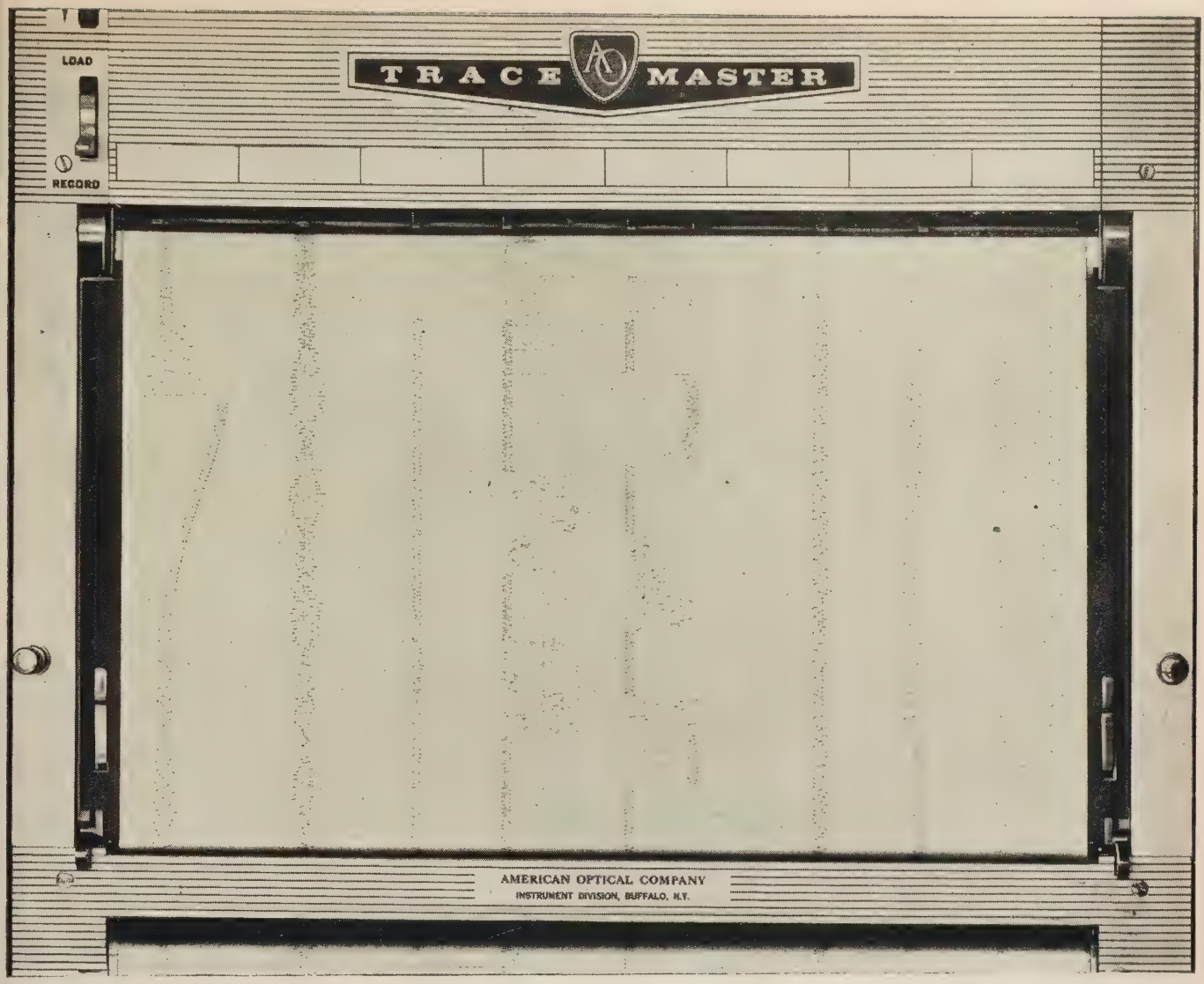
CAMERA has Kerr-cell triggering

A new Kerr-cell instrumentation camera system, Model KSC-51/A, has been announced by **Electro-Optical Instruments, Inc., Dept. S/A, 2612 E. Foothill Blvd., Pasadena, Calif.** It features addition of a trigger pulse generator to the control unit circuitry of the KSC-51 for greater capability.

The pulse generator permits operation from an external low voltage trigger source, as well as from an internal 60-cycle source. It has three output pulses with the following characteristics: a 50-V pulse from a high impedance source to provide time-base generation; a fixed 300-V pulse that provides Kerr-cell triggering action into a 50-ohm load; and a 100/300 V variable output pulse for initiating other phenomena or instrumentation.

No. 309 on Reader Service Card

No. 125 on Reader Service Card



AO Trace-master provides twice the definition of any other direct writing technique

The unique direct-carbon-transfer writing method produces a trace from 2 to 3 times finer than any other direct-writing technique. This allows twice as many lines per millimeter . . . **twice the definition!** Resolution is unsurpassed . . . each line is uniform in width and contrast, revealing the most minute variations in the phenomena measured with utmost fidelity. This writing technique combined with the advanced pen-motor design produces a wider frequency response **at larger amplitudes.** Continuous recording of data can be displayed simultaneously on 8 channels . . . up to 8 independent event markers can be added. Ten chart speeds — 0.1 to 500 mm/sec — provide a 5000:1 chart speed ratio.

The AO Tracemaster has become the new standard of performance for these and many other reasons . . . write now for the full story!

American Optical
COMPANY

INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

No. 126 on Reader Service Card

KEARFOTT VERTICAL-SENSING ELEMENTS

Two basic precision vertical-sensing elements are available, pendulous or bubble types. These devices can be applied to any vertical-sensing application requiring an electrical output indicative of displacement from gravity vertical. Sensing elements, employing electrolytic or electromagnetic pickoffs, are made in single- and two-axis types for either signal or power applications. A servo motor may be directly controlled by the power type for low-cost, moderate-accuracy applications. In addition to these proportional units, on-off switching devices are available. Precision leveling to a few seconds of arc may be accomplished with the signal types and external amplification.

The pendulous vertical-sensing elements employ a frictionless flexure suspended mass. Displacement from vertical, sensed about two orthogonal axes results in proportional phase-sensitive ac voltage outputs. The bubble types, of glass and noble-metal construction, contain an electrolyte and a gas bubble which acts as the gravity sensor. High reliability, low cost, and excellent resistance to vibration are achieved.

CHARACTERISTICS

	Part Number	Type	Excitation	Range	Null Repeatability
Pendulous	B1802-01	Electrolytic	400 cps*	1.3°	4 min.
	C70 1807 000	Electromagnetic	10 v 1000 cps	20 min.	4 sec.

	Part Number	No. Axis	Type Output	Range	Null Repeatability
Bubble	C70 1808 000	1	Proportional*	1° nominal	To 4 sec.
	A1800-01A-A	2	Proportional*	1° nominal	5 arc min.
	228571-1	1	On-Off*	Switches at 0.75°	Range 75-135 arc min.

NOTE: *Above designed for 400 cps., but higher frequencies possible. Excitation voltage is a function of circuit impedance.

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

TRAILER for oxygen recharging

A simplified oxygen servicing trailer for recharging of oxygen or nitrogen cylinders is available from **Zep Aero, Dept. S/A, 109 Sheldon St., El Segundo, Calif.**

The trailer is described as complete with all necessary equipment to recharge aircraft fitted with outside filler valves, thus eliminating removal of oxygen cylinders. It is designed to carry seven large cylinders, six for oxygen and one for nitrogen. It includes adapters for filling portables of various types.

No. 310 on Reader Service Card

LEAK DETECTOR for vacuum technology

A lower-priced mass spectometer leak detector for reliability control in the vacuum technology industry is available from **Crodsby-Teletronics Corp., Dept. S/A, 54 Kinkel St., Westbury L. I., N. Y.**

The Model 600 leak detector incorporates a double magnetic analyzer and a newly developed ion source and detector unit to reduce background, permitting a substantial sensitivity increase, according to the manufacturer. Minimum detectable leak rate is 1x-10/12 standard cu cm/sec in terms of air leakage. Sensitivity range is 5x10/11 to 5x10/8 standard cu cm/-sec for full scale deflection. Speed of response depends on the inlet system used. With a leak connected directly to the inlet, the time for ⅔ of maximum response is 2 sec or less. The equipment is sensitive to helium only, so presence of other gases cannot give false indications.

No. 311 on Reader Service Card

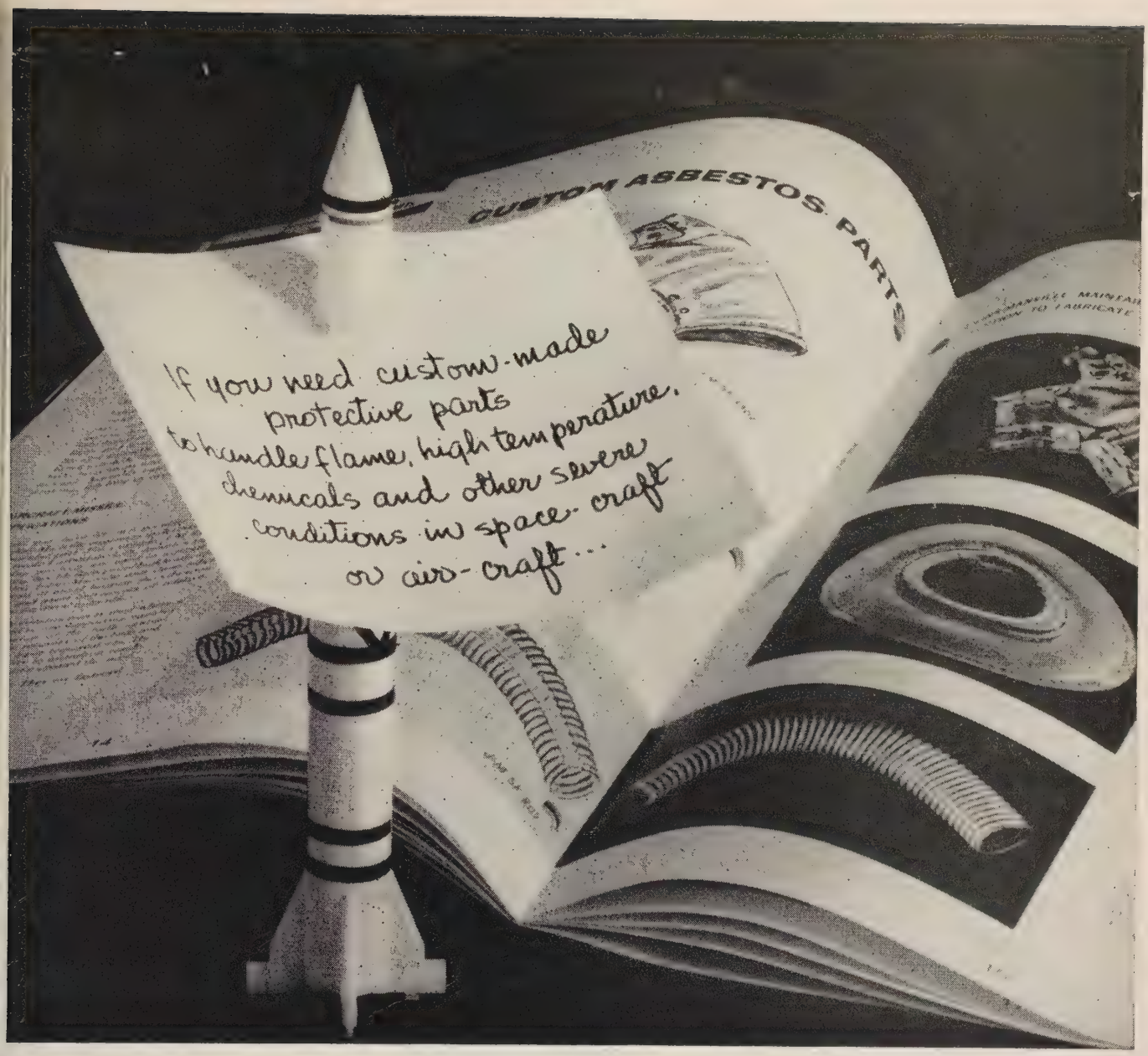
ALTITUDE CHAMBER for components testing

A 20x20x20 ft altitude chamber for testing electronic and hydraulic components has been developed by **Industrial Refrigeration Co., Inc., Dept. S/A, 8940 Ellis Ave., Culver City, Calif.**

The Inreco chamber has an ultimate altitude of 200,000 ft and a temperature range of −100 to 240 deg F. Pulldown time to −90 deg F is 45 min, and heat-up time to 240 deg F is 15 min. Evacuation time to 150,000 ft is 30 min. The chamber has a cold-wall liner for maintaining low temperature simultaneously with high altitude. A manometer is supplied for indicating altitude.

No. 312 on Reader Service Card

No. 127 on Reader Service Card


If you need custom-made protective parts to handle flame, high temperature, chemicals and other severe conditions in space-craft or air-craft...

...you'll want a **FREE** copy of this new J-M booklet!

The Johns-Manville Custom Asbestos Parts group specializes in fabricating units to safeguard against flame and heat...where durability, flexibility and strength are required.

These ready-to-install Custom Asbestos Parts can be made up from asbestos cloth, tadpole tape, metal mesh or metal sheet...in whatever combination your design conditions require. Surface treatments of the asbestos fabrics include flameproof Neoprene–base compound, Silicone cements and rubbers, Du Pont Teflon, Viton, and aluminum. Assembly can involve cementing, braiding, weaving, stitching or oven curing.

The made-to-order protection of J-M Custom Asbestos Parts takes the hazards out of "hot-spots." Each is especially designed to handle its specific job. The examples you see on this page are only a few of the parts now serving in missiles or aircraft. The full story of Custom Asbestos Parts is in J-M's new 28-page booklet, which also describes the entire range of J-M Packings, Gaskets, Textiles and Friction Materials for air and space craft.

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JOHNS-MANVILLE JM

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COMBINE VIBRATION AND SHOCK TESTING

Model ST-300

IN ONE COMPACT 250 FORCE-POUND INSTRUMENT

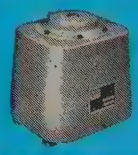
FOR LARGE COMPONENTS AND SMALL SUBSYSTEMS . . . the new ITT ST-300 offers a 250 force-pound exciter for vibration *and* shock testing. This latest in a series of dynamic new vibration equipment utilizes the unique concepts of lateral motion excitation and air-bearing support—both developed by ITT engineering and proved on ITT's other vibration exciters of the 100 and 200 Series.

The exceptionally flat frequency response of the ST-300 permits precise testing without the need for elaborate compensating devices. Natural resonances are unaffected by table loadings. In addition, by checking shock *and* vibration on the same instrument, testing time and cost are substantially reduced. Other significant features of the ST-300 include:

- *no significant distortion throughout normal test range*
- *first major resonance above 5 Kc*
- *useful frequency from 5 cycles to 50 Kc*
- *shock testing to over 5,000 g's*
- *table size: 5" x 8"*

For complete information and applications data, call an ITT Instruments representative or write for Data File SA-1426-2

Other ITT vibration exciters include:



ST-150 for testing one ounce loads to over 100 g's

ST-100 for small component production testing and accelerometer calibration

ITT **Industrial Products Division**
International Telephone and Telegraph Corporation
15191 Bledsoe Street • San Fernando, Calif. • EMpire 7-6161
power conversion • instruments • closed circuit TV • avionics • mobile radio/telephone

CONTROL VALVE is self-draining

A self-draining control valve for missile fuel plants and aerospace ground facilities has been announced by **The Annin Co. Div., Worthington Corp., Dept. S/A, 1040 S. Vail Ave., Montebello, Calif.** It is designated Model 1900.

The valve's body and trim are designed so that all surfaces slope downstream, making it completely self-draining in either horizontal or vertical position. Its specifications include: connections—screwed 300-lb sizes ½ to 2 in., and flanged 150 lb, 300 lb sizes ½ to 6 in.; body material—carbon steel, stainless type 304, 316, and 347, Hastelloy "B" and "C," Monel, others available.

No. 313 on Reader Service Card

TACHOMETER PICKUP is explosion-proof

An explosion-proof magnetic tachometer pickup suitable for aircraft engines and test stands has been announced by **The Meriam Instrument Co., Electronic Div., Dept. S/A, 10920 Madison Ave., Cleveland 2, Ohio.**

It produces high amplitude, low modulation, sine wave signals in place of existing AC or DC analog signals, proportional to speed and rpm. Standard frequencies are 60 or 20 impulses per revolution, and adaptation to a range of 1 to 240 impulses per revolution is possible. The unit has heat-treated cast aluminum alloy housing, weighs 2½ lb. Its speed range is 75 to 10,000 rpm, and its output voltage more than 1 V rms at 100 rpm.

No. 314 on Reader Service Card

TESTER for liquid gages

Entire liquid quantity gage systems can be tested and calibrated with the self-contained, portable "Quan-Test" from **Consolidated Airborne Systems, Inc., Dept. S/A, 120 Denton Ave., New Hyde Park, N.Y.**

The unit offers a single, built-in calibration for both sensing and indicating component readings. Probe capacitances from 0-5000 uuf, accurate to ±0.15 percent of full-scale, are measured by a servo-actuated capacitance bridge. Direct readings to 0.05 per cent are possible. Resistance measurements between all probe elements are determined by the 0-10,000 megohm meter, accurate to 10 per cent of individual readings.

No. 315 on Reader Service Card

No. 129 on Reader Service Card

MICROWAVE TESTER
measures frequency changes

Microwave stability tester model 5024 was shown at the ecent IRE convention. The tester is reported able to meas-ıre frequency variations of 1.5 parts in ten billion. A ɔrimary feature of the 5024 is its display of FM deviation rom a minimum full scale rate of 10 cps to a maximum f 30 kc, says **Laboratory For Electronics, Inc., Dept. S/A, 1079 Commonwealth Ave., Boston 15, Mass.**

Available microwave plug-in heads are: S and L band—000 to 3200 mc at 0 to —35 dbm; C band—5000 to 6100 nc at 0 to —25 dbm; X band—7000 to 10,000 mc at 0 to —20 dbm; and X band upper range—9600 to 11,000 mc at) to —12 dbm. Other specifications are: minimum measur-ıble FM deviation 0.2 cps at 30 mc and 120 kc, 0.3 cps ıt L band, 0.5 cps at S band, 0.7 cps at C band, 1.5 cps ıt X band, and 2 cps at Ku band.

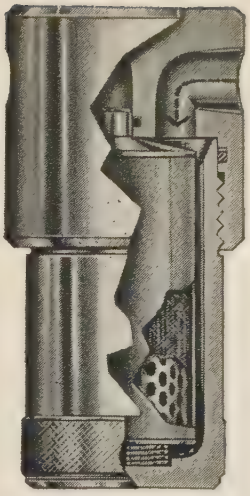
No. 316 on Reader Service Card

TAPE RECORDER ANALYZER
is self-contained

A tape recorder analyzer, capable of performing all meas-ırements to determine operational status of a recorder, has ɔeen packaged into a single solid state unit. **Telemetrics, Inc., Dept. S/A, 12927 S. Budlong Ave., Gardena, Calif.,** says the unit eliminates multiple test setups, thereby saving ɪime and personnel. The unit measures start and stop distances, dynamic skew, and dynamic speed variation ap-ɔearing as wow and flutter.

Accuracies for distance measurements are 0.01 in. resolu-ɪion to 0.003 in., skew measurement is 2 per cent at 1 volt ɔeak per microsecond, speed variations are 1 per cent on 100 ms range, 0.2 per cent on 3, 30, and 200 ms, and 1 second. The unit is available for standard rack mounting with 10½-inch panel, or as a portable unit.

No. 317 on Reader Service Card



Looking for a standard microfilter rated up to (or above) 10,000 psi?

LOOK INTO THIS FD DESIGN**

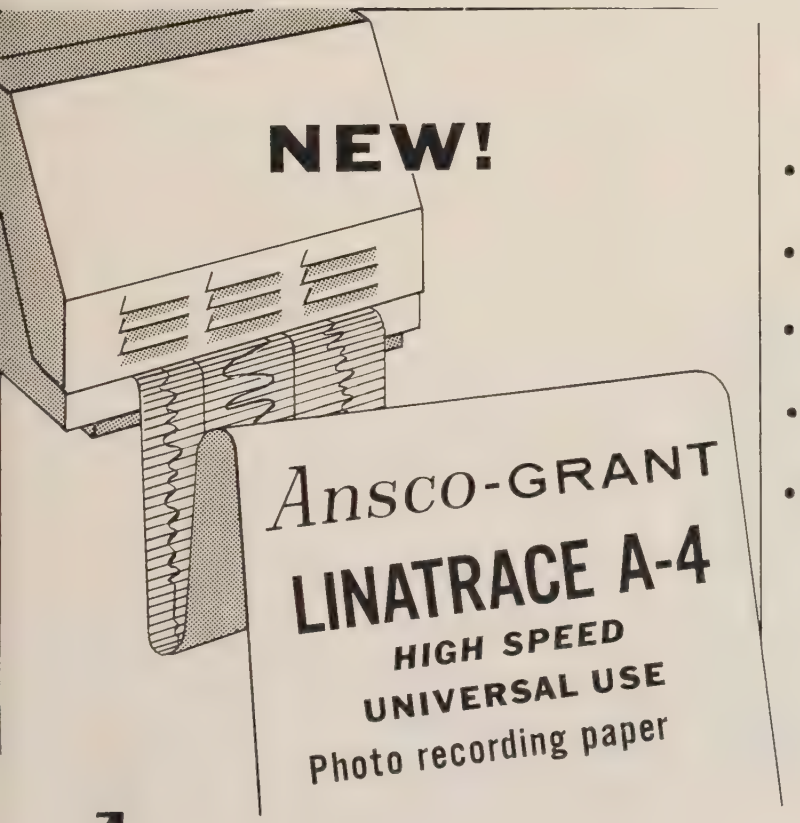
Note (1) flow contoured inlet; (2) eccentric location of outlet; (3) deflection surface that guides stream around element. Result? At 10,000 psi inlet pressure, ½-inch filter passes 1000 SCFM (nitrogen at 70°F) without pushing ΔP above 50 psi. Dynaloy* C sintered stainless steel element removes 98% of all 10-micron particles (finer or coarser elements also supplied). Unit handles fluids from —320°F to +400°F. Available in ¼-inch to 1-inch sizes. Minimum burst pressure 36,000 psi. For detail sheet, for brochure (D-5), please write.

*Trade name of FLUID DYNAMICS Incorporated **Pat. Applied for

FD® FLUID DYNAMICS INCORPORATED

Dept. SA-9, 90 West St., New York 6, N. Y.

No. 130 on Reader Service Card



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- **SPEED** it has the speed to record high frequencies and yet it
- **CLARITY** possesses the latitude to be used on slower applications,
- **LATITUDE** covering the widest range of writing speeds. No need to
- **ECONOMY** stock several speed papers. New Linatrace A-4 allows
- **PERFORMANCE** you to standardize with one high-speed paper that can be "universally used."

WRITE TODAY! for your copy of catalog R-61

Ansco

BINGHAMTON, NEW YORK

A DIVISION OF GENERAL ANILINE AND FILM CORPORATION

No. 131 on Reader Service Card

For details on equipment listed in this section, write in item number on Reader Service Card

THREE-DIMENSIONAL DATA DISPLAY CAN BE SEEN FROM ALL SIDES

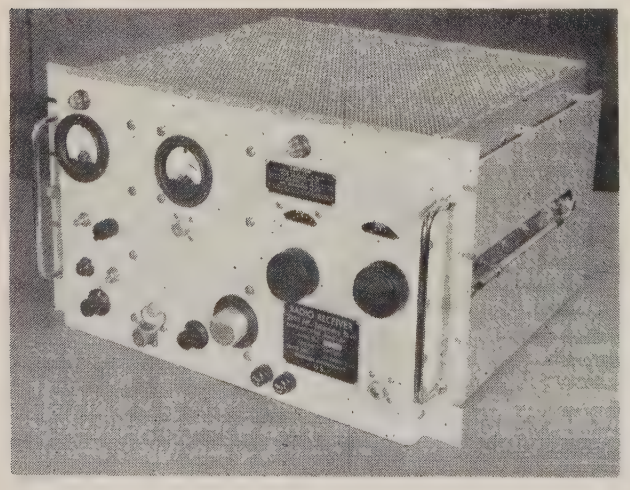
A new technique of three-dimensional data presentation has been developed by ITT Corp., ITT Federal Laboratories Div., 500 Washington Ave., Nutley, N.J.

Instead of the usual stereoscopic method, which depends upon a fixed point-of-view, the ITT system produces the three-dimensional picture by rotating the image of a time-sequenced two-dimensional display, using a cathode-ray tube to transduce the electrical signal to light. This method has been found to be the most flexible in generating display formats and grid reference coordinates, since the intermediate conversion to light promises true color capability.

The system does not use an evacuated enclosure. The display can be viewed from all sides and above, and can be used both for "live" presentations and for presentations from stored data.

Applications investigated to-date at ITT, using quantized data or 3-D radar video, include displays of satellite orbit, air traffic, and space navigation where a display of the flight path is required. **68**

Telemetry Receiver Features Novel Circuitry and Simplicity



The Model 9-100 double-conversion superheterodyne telemetry receiver for the 2150-2350-mc band includes a phase-lock demodulator; a phase-locked, first-injection klystron oscillator; and a low-noise crystal mixer using a balanced pair of 1N21F diodes. Despite its novel circuitry, claims Radiation, Inc., Melbourne, Fla., the 9-100 is operationally simple and has shown excellent reliability and operational stability in extensive tests. Development of the receiver was sponsored by ASD to meet the need for communications system components in the 2200-mc band.

Bandwidths can be selected with a front-panel switch that has positions optimized for standard PDM-FM, FM-FM, and PCM-FM signals with 500-kc bit rates and ±250 kc carrier deviation. A fourth switch position permits the use of plug-in filters for passing particular non-standard signals that fall within the actual IF bandwidth (one megacycle), peak phase-lock demodulator deviation capacity (±250 kc), and video bandwidth (250 kc) of the receiver.

The 9-100 is designed for the easy addition of conical scan circuitry and a synchronous demodulator for AM signals. Operating from a 50-ohm input, it has an overall noise figure of 6.25 db maximum and provides both detected and undetected video output signals as well as the output signals required by the servo systems of self-tracking antennas.

The receiver is entirely self-contained and is designed for mounting in a standard 19-in. relay rack, requiring 10½ in. vertically and 14 in. in depth. Power consumption is about 450 va from a standard 115-V, 60- or 400-cps source. **53**

preview

Miniature Ceramic IF Filters for Transistor or Vacuum-Tube Circuits

A miniature ceramic filter has been developed by the U. S. Sonics Corp., 63 Rogers St., Cambridge 42, Mass. Two 455-kc IF models will be introduced, one for transistor circuits, the other for tube circuits.

These filters can also be supplied with a wide variety of other characteristics, including center frequencies from 150 kc to 1 mc, bandwidths (at 6-db points) from 1-20 per cent of center frequency, and input and output impedances ranging from 50 to 15,000 ohms. Performance is claimed to exceed that of many currently available quartz filters, with costs as low as one-third of quartz-filter prices.

Advantages of the filters include small size, permanent tuning, axial leads that permit automatic assembly on printed circuit boards, high temperature stability (better than 0.1 per cent from room temperature to 80 deg C for any electrical parameters), high shock and vibration resistance and low microphonics. Power loss is typically only 1 db, due to the ceramic filter's high tolerance to impedance mismatch. **72**

equipment in brief

LOG IF AMPLIFIER has input trimmer control

This is one of a series of LIFV-30, 60, and 90 logarithmic response IF amplifiers that have center frequencies of 30, 60, and 90 MC. According to **W. L. Maxson Corp., Dept. S/A, 475 Tenth Ave., New York 18, N.Y.**, all models are designed to have a low noise figure wide dynamic range, and high gain.

Special input trimmer controls permit standard units to be matched to many different crystal capacity outputs.

No. 253 on Reader Service Card

TAPE-TO-TAPE CONVERTER has wide application

This converter accepts digital magnetic tapes from instrumentation systems as input data. The magnetic tape output can be fed to IBM 650, IBM 704, and UNIVAC Scientific 1103A computers, says **Computer Control Co., Inc., Dept. S/A, 983 Concord St., Framingham, Mass.** The modular construction will permit expansion or modification to handle tapes of other computers such as Honeywell 800, IBM 709 and 7090, and RCA 601, says the company.

Provision is included for full control over code conversion, word length, character placement, block length, word arrangement, suppression or selection of input blocks, etc. It can handle continuous data tapes, tapes with or without sprocket channels, inter-block spacing, and return-to-zero and non-return-to-zero forms of recording.

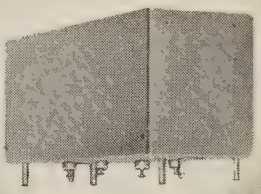
No. 254 on Reader Service Card

SOLID-STATE COMPUTER has battery supply

Normally, this solid-state PB 250 computer operates from a standard 115-V power line. In an emergency, however, it can be operated for more than one hour off its own battery power supply, says **Packard Bell Computer, Dept. S/A, 1905 Armacost Ave., Los Angeles 25, Calif.**

The battery supply is regenerated continuously by trickle charging. Sealed cells in the battery are said to operate for over five years without servicing.

No. 255 on Reader Service Card



BULOVA
S S BAND
CRYSTAL
FILTERS

With the ever increasing demand for Single Side Band Communication Systems for High Frequency Voice communications, fascimile and multi-channel frequency shift keying teletype operation, Bulova Electronics added Model 283 Single Side Band filter to their standard line of crystal filters.

Designed to surpass the Signal Corps SM-D-180214 and SM-D-180215 Single Side Band Filter Specifications, the new Bulova Model 283 features an unusually flat passband, low insertion loss and operation over a large temperature range.

General Specifications include: Carrier Frequency—100kc; Carrier Attenuation—13 db; Maximum Ripple—±0.5 db; Insertion Loss—less than 5.0 db; Input Output Impedance—1.5 k Ω balanced or unbalanced; Operating Temperature Range—−40°C to +70°C.

Type 10WL Lower Side Band—Model 283 features Passband—±0.5 db from 94kc to 99.875kc and Minimum 60 db Attenuation at 100.2kc and above.

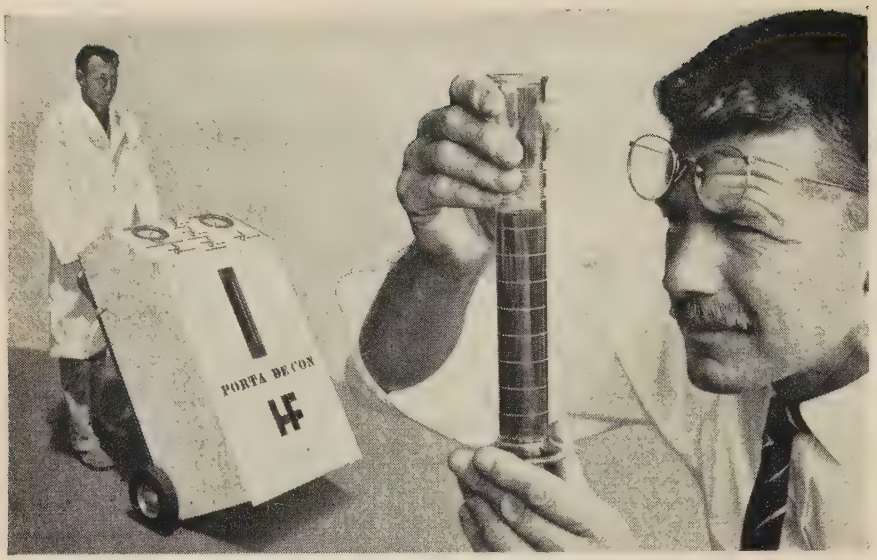
Type 10WU Upper Side Band—Model 283 features Passband ±0.5 db from 100.125kc to 106kc. Minimum 60 db Attenuation at 99.8kc and below.

The new Bulova Model 283 can be driven from a balanced or unbalanced source and its low input and output impedance make it readily adaptable to transistor circuitivity.

For additional information or application assistance, write Department 2155, Bulova Electronics, Woodside 77, N.Y.

BULOVA
ELECTRONICS
DIVISION

No. 132 on Reader Service Card



DECONTAMINATE HYDRAULIC SYSTEMS TO 2 MICRONS

PORTA DE-CON removes particulate contaminates down to 2 microns and dehydrates (25 ppm) hydraulic systems and test stands... fast. Example: a Navy jet fighter's contaminated hydraulic system was a 12 day clean-up. Now, Porta De-Con gets it back on the line in 2 hours! Simple, one-man (non-tech) operation. Saves its low first cost in reduced labor, shorter down-time of expensive gear. Handles JP, RP fuels, Oronite, marine hydraulic fluids, Mil H-5606 fluids and dielectric oils. Get the full story, with low prices, by circling reader card now.

PACIFIC DIVISION HOUSTON FEARLESS CORPORATION

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No. 133 on Reader Service Card

NANMAC CORPORATION

is proud to introduce the . . .

"PLASTIC THERMOCOUPLE"

MODEL-P

The body of the Model "P" thermocouple can be fabricated from any plastic, plastic-mineral composites, non-metal, alloy, or special proprietary material. Thus surface or in-wall temperatures of a wide variety of materials can be measured accurately without disturbing the normal heat distribution pattern caused by differences in thermal properties. Examples of materials successfully used in the Model "P" include: plexiglass, asbestos phenolics, graphite, copper, molybdenum and special proprietary plastics.

FEATURES

- √ Response time—less than 10 microseconds to transient temperatures.
- √ Thermal junction maintained even during erosion.
- √ Temperature range from —320° F to over 5000° F.
- √ Pressure range to over 5000 PSI.
- √ Two-dimensional thermal junction for accurate location of point of measurement.
- √ Thermocouple constructed of flat ribbon wires and mica insulation.

(Actual Size)

OVER 5000° F.!

NANMAC CORPORATION

P.O. BOX 8 INDIAN HEAD, MARYLAND

NANMAC THERMOCOUPLES

WRITE FOR BULLETIN TB161

No. 134 on Reader Service Card

MINIATURE RECORDER for data acquisition

This recorder will handle data from dc to 100 kc at a tape speeds of up to 30 ips. **Pacific Electro Magnetics Co., Dept. S/A, Palo Alto, Calif.,** says the higher the data frequency the lower the tape speed. The PMR-500 recorder is 5x7x10.5 in. in size and weighs 10 lb.

Precision 5-inch reels hold 900 ft of 1-mil tape for six minutes recording at 30 ips and up to 96 minutes at 1-⅞ ips. Performance specs: wow and flutter 0.2 per cent rms dc to 300 cps; frequency response 300 cps to 100 kc ±3 db, direct; dc to 10 kc, FM; power 22-30 bolts dc, 20 watts max; 115 vilts 60 cycle.

No. 318 on Reader Service Card

MOBILE DATA HANDLER for computers

This mobile data handling system can collect data on speeds, fuel flow, temperatures, pressures, etc., and process and prepare this information for direct entry into computers. It is expected to considerably reduce data handling costs, says **Radiation Inc., Dept. S/A, Melbourne, Fla.** The RADAC I system will also save computer time, says the company, because it permits engineers a "quick look" at the data before computation so that they can select channels and times for final analysis.

RADAC I has magnetic tape outputs in formats for direct use with the IBM 650, 704, and 1260 as well as the large IBM 7090. The system handles up to 48 analog inputs with a resolution of ±10 microvolts to ±1 per cent accuracy. The digital converter has a maximum word rate of 3.8 kc.

No. 319 on Reader Service Card

TUNABLE MAGNETRON uses low weight magnet

This voltage tunable magnetron operates as an r-f power source in the 2900 to 3100 megacycle range. It weighs 1.5 lb, says the **General Electric Power Tube Department, Dept. S/A, Schenectady, 5, N.Y.** It is just more than 3 in. in diameter and a little less than 1 in. in height.

According to GE, the size and weight can be attributed to a compact bowl-magnet design. The Z-5337 VTM has a mimimum CW power output of 4 watts across its design frequency range. It can be electronically tuned over the complete range at a rate of 2.6 megacycles per volt.

No. 320 on Reader Service Card

New Daystrom Series 319 Potentiometers Can Be Adjusted In Seconds After Ganging

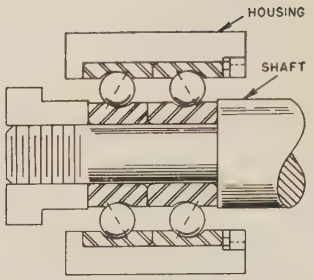
It can be done. **24 cups of the Daystrom 319 Series potentiometers ganged within six inches.** ***Most important,*** **phasing of individual cups can be accomplished after installation, and with no interference to adjacent cups. Results: finite adjustments • many hours and dollars saved in installation costs • re-phasing in a matter of seconds!—■—The Daystrom 319 Series is ideal for multi-channel applications. Exclusive Daystrom design techniques result in unusual stability to shock, vibration, and other severe environmental influences. The 319 is rated at 2 watts in *still air*, operates over a range of −55°C, to 150°C, is available in resistances from 100 ohms to 200 kilohms, and meets or exceeds all applicable MIL Specs. Send for further data.**

DAYSTROM, INCORPORATED
POTENTIOMETER DIVISION
ARCHBALD, PENNSYLVANIA • LOS ANGELES, CALIFORNIA

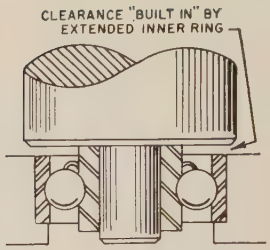
No. 135 on Reader Service Card

No.1

ideas you can use in working with bearings



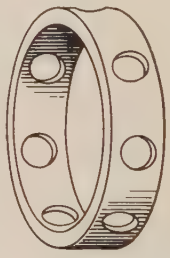
The problem of confining radial and axial shaft displacement to an absolute minimum in instruments such as gyroscopes can be solved readily by the use of duplex bearings. These "matched pairs", constructed to eliminate axial play, do away with painstaking and time-consuming use of shims mounted against one face of single bearings. Duplex pairs are matched by NHBB to customer specifications.



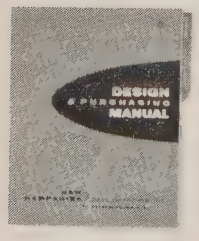
When small bearings are mounted against surfaces such as flat gear faces there must be sufficient clearance to allow the outer ring to revolve independently, especially when there are thrust loads and axial play. NHBB extended inner ring bearings (the inner ring is .0312" wider than the outer) provide ample clearance. They eliminate the need for — and provide a firmer, more precise bearing seat than — washers, sleeves or gear hubs.

Miniature and instrument bearings must be protected in the user's plant so that the precision built into them will be fully realized in an assembled instrument. One form of protection is the use of rubber finger cotts by everyone handling bearings to prevent the corrosion of polished surfaces from skin acids — a serious threat to optimum bearing performance.

Radial play — the displacement of one ring with respect to the other along the diameter of a bearing — is important in the successful application of precision bearings and should be specified on orders. A range of .0002" to .0005" is satisfactory for most applications. The minimum clearance should be .0001" and the total spread from min. to max. should be at least .0002".



Machined type retainers of laminated plastic permit higher speeds than stamped metal retainers and, because of the porosity, act as lubricant reservoirs. Bearings with machined retainers can withstand thrust load in one direction only because either an inner or an outer land must be ground off to permit assembly. Since most applications involve a pair of bearings which can be mounted to oppose one another this limitation is seldom a disadvantage.



150-page Design and Purchasing Manual is the most comprehensive treatise on miniature and instrument ball bearings ever published. Write for your copy — on your company letterhead, please.

TYPICAL SPECIFICATIONS OF NHBB EXTENDED INNER RING BEARINGS

BORE	OUTSIDE DIAMETER	WIDTH INNER	WIDTH OUTER	BEARING NUMBERS	RADIUS	C RATING
.0469 .0550	.1562 .1875	.0937 .1094	.0625 .0781	SROEE SRIEE	.005 .005	19 28
.0781 .0937	.2500 .1875	.1250 .0937	.0937 .0625	SRI-4EE SR133EE	.006 .005	39 21
.0937 .1250	.3125 .2500	.1406 .1250	.1094 .0937	SR1-5EE SR144EE	.006 .005	64 36
.1250 .1250	.3125 .3750	.1406 .1406	.1094 .1094	SR2-5EE SR2-6EE	.006 .006	66 66
.1562 .1875	.3125 .3125	.1406 .1406	.1094 .1094	SR155EE SR156EE	.005 .005	35 35
.1875 .2500	.3750 .3750	.1562 .1562	.1250 .1250	SR166EE SR168EE	.008 .008	82 44
.2500 .3125	.5000 .5000	.1562 .1875	.1250 .1562	SR188EE SR1810EE	.010 .009	120 60

ALSO AVAILABLE IN FLANGED AND SHIELDED CONSTRUCTION.

NEW HAMPSHIRE BALL BEARINGS, INC.

PETERBOROUGH, N. H.

No. 136 on Reader Service Card

new instrument bearings let you beef up the shaft without increasing bearing O.D.

Here are four new opportunities to design shaft-to-housing relationships not possible with other bearings. Thinner cross sections permit extra large bore-to-O.D. ratios.

This new series is manufactured to ABEC-5 precision standards or better, of 440C stainless steel, with plastic crown retainers which act as lubricant reservoirs.

BORE +.0000 −.0002	OUTSIDE DIAMETER +.0000 −.0002	WIDTH +.000 −.001	BEARING NUMBER	RADIUS	BALLS NO.	BALLS SIZE	C RATING
.3750	.6250	.1562	SR620T	.010	12	1/16	81
.5000	.7500	.1562	SR824T	.010	16	1/16	95
.6250	.8750	.1562	SR1028T	.010	18	1/16	98
.7500	1.0000	.1562	SR1232T	.010	22	1/16	108

NEW HAMPSHIRE
BALL BEARINGS, INC.
PETERBOROUGH, N. H.

ION PUMP USED for ultra-high vacuum

This vacuum ion pump is for use in the ultra-high vacuum field. It is an electronic gettering pump with a three-electrode construction for higher pumping speeds and elimination of pressure surges when operating against inert gases, according to **Consolidated Vacuum Corp., Dept. S/A, 1775 Mt. Read Blvd., Rochester 3, N. Y.**

The pump is said to be especially useful for semi-conductor processing, vacuum-tube processing, electron microscopes, particles accelerators, and field emission, electron beam and molecular beam studies. It has a nominal pumping speed of 300 liter/sec with an ultimate pressure of 2×10^{-10} mm Hg.

No. 321 on Reader Service Card

SINGLE SIDEBAND RECEIVER is crystal controlled

This SX-116 crystal-controlled strip receiver can be operated on either the upper or lower sideband, on both sidebands independently, or on AM or CW. As described by **The Hallicrafters Co., Dept. S/A, 4401 W. 5th Ave., Chicago 24, Ill.**, a built-in four-crystal oven provides a frequency stability of one part in 10^6 per month on each of four preselected bands that span a 230 mc range.

Interchangeable crystal lattice filters for sideband selection can be supplied for any desired pass-band characteristic, says the company. Fast attack and slow release AGC circuitry results in less than two db gain variation for signals ranging from 2 microvolts to 2 V.

No. 322 on Reader Service Card

RECORDER/REPRODUCER for mobile application

This two-channel, two-speed compact magnetic tape recorder/reproducer, Model R168-C is designed primarily for mobile use. It can be utilized in vehicles, aircraft or aboard ship, says **American Concertone, Inc., Dept. S/A, 9449, W. Jefferson Blvd., Culver City, Calif.** The unit also can be used as a portable or rack-mounted laboratory recorder.

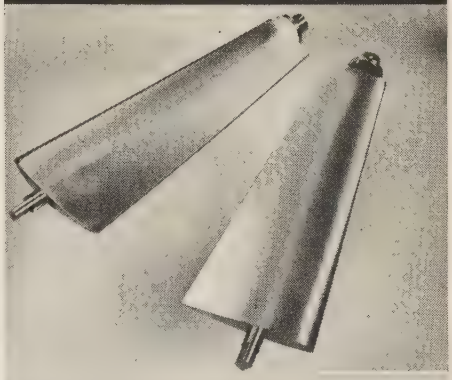
A number of configurations are available. Variations can be secured on tape width, number of channels, tape speeds, etc. It accepts up to 10 ½ in. reels with the standard NAB hub.

No. 323 on Reader Service Card

Stalker

lighter weight
lower cost
precision

SHEET METAL FABRICATIONS



Much time, effort and cost go into developing the processes necessary to produce satisfactory sheet metal fabrications. *The Stalker process has been PROVEN — with the production of many quality blades and vanes, as well as other brazed sheet metal assemblies.* **Stalker Orthobrazed stainless steel or super-alloy fabrications — such as compressor and turbine blades — are** *dimensionally and thermally stable.*

Produced to closer tolerances than the usual machined blades, nose radii of Stalker-produced blades feature a closer dimension and uniformity from blade to blade. **The Stalker forming techniques also eliminate distortion during brazing and heat treat operations. Blades hold their precise shape because of the inherent thermal stability which insures Stalker quality. The Stalker quality control and inspection system is U.S.A.F. approved.**

Stalker personnel, facilities and techniques are now available for the use of firms having precision sheet metal fabrication problems.

THE STALKER CORPORATION

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Flexible temperature range

-100° F TO 500° F

COHRlastic R-10470 silicone sponge rubber sheets have a dense, uniform, non-absorbing closed cell structure highly suitable for soft gasketing, vibration dampening, fairing strips, pads, cushions and other applications where resiliency at extreme temperatures is required. It may be bonded to metals, plastics, fabrics or silicone rubber. COHRlastic R-10470 possesses superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening.

COHRlastic R-10470 meets: *AMS 3195; AMS 3196; Boeing BMS 1-23; Martin–MMS C451 and MB 6103; Scintilla 9-3143; Bendix ES-0709; Douglas DMS 1597; Lockheed LAC 1-924; Minneapolis Honeywell 6384-3 and Sperry Gyroscope P.691.764 Type HTM.*

AVAILABLE FROM STOCK: in 12″ x 12″ sheets and 24″ x 24″ sheets — 1/16″ through ½″. Special thicknesses and sheet sizes up to 30″ x 30″ and 24″ x 48″ can be made to order. COHRlastic R-10470 is sold nationally through distributors.

CHR PRODUCTS INCLUDE: Airframes and engine seals, firewall seals, and coated fabrics; Silicone rubber moldings and extrusions, silicone rubber sheets, silicone sponge rubber; silicone cements; conductive gasketing; and Temp-R-Tapes — pressure-sensitive, thermal curing Teflon* Fiberglas and silicone rubber tapes.

FREE SAMPLE and folder — write, phone or use inquiry service.

Leader in Fabrication of Silicone Rubber Products

CHR CONNECTICUT HARD RUBBER CO.

*Reg. T. M. DuPont

Main office: New Haven 9, Connecticut

TELEMETRY FILTER weighs 25 grams

This IRIG-type miniature telemetry filter weighs 25 grams. It has a maximum volume of just 0.6 cu in. for the 400 cycle, channel one application, says **Genistron, Inc., Dept. S/A, 6320 Arizona Circle, Los Angeles 45, Calif.** The filter is designed for all telemetry applications, with particular emphasis on space and weight conservation for airborne systems.

The unit features a 3-60-1 shape factor for 15 db attenuation. Standard impedance level is 10,000 ohms. The insert-mounting filter is temperature rated for the range —55 to +85 deg C.

No. 324 on Reader Service Card

MICROWAVE TETRODE delivers 40 W at 3000 mc

A high-power microwave tetrode has been developed which reportedly extends the state of the art. **The General Electric Power Tube Department, Dept. S/A, Schenectady 5, N.Y.** announced that they have a Type Z-5267 planar tetrode which produces 40 W of useful output power at 3000 mc, with a gain of 7.5 db. The Z-5267 is said to have an operating efficiency of 25-30 percent in the 3000-mc region.

The metal-ceramic tube, which has been shock tested at 450 g, weighs 4 oz, has a diameter of 1¾ in., and is slightly less than 3 in. long. In typical operation at 3000 mc, the DC plate voltage is 1000 V, DC screen grid voltage is 300 V, DC control grid voltage is —6 V, and the DC plate current is 160 ma. Bandwidth is about 25 mc.

No. 325 on Reader Service Card

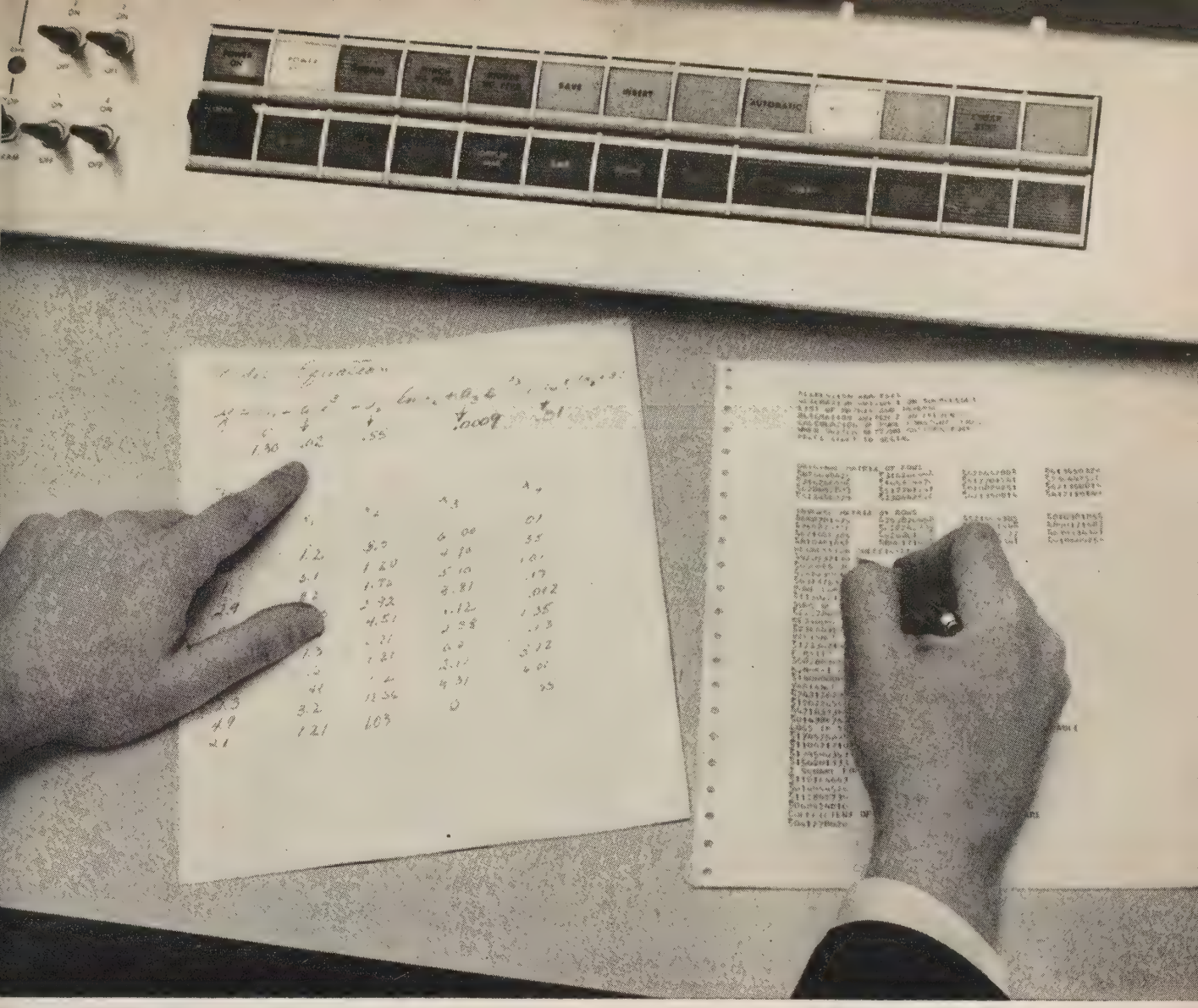
DIGITAL CONTROLLER is solid-state unit

This digital, set-point, on-off temperature controller is completely solid-state design. A three-wire nulling bridge provides a linearized set point, maximum stability, and freedom from line connection problems, according to **Winsco Instruments & Controls Co., Dept. S/A, 11789 W. Pico Blvd., Los Angeles 64, Calif.** Its dimensions are 7 x 5 x 4 in.

The input is a 500-ohm platinum resistance transducer which is provided with the controller. The output is a set of relay contacts which can be made to vary from 2 to 15 amps at 115 V AC. The instrument covers the range from 0-2000 deg F.

No. 326 on Reader Service Card

No. 138 on Reader Service Card



Want to find the coefficients? It's easy with the new Regression Analysis program for the IBM 1620

Here's another program offered free-of-charge to users of the IBM 1620 Data Processing System. It gives you the kind of results you might expect only from a much more expensive computer. But users of the 1620 know that its low rental cost is deceptive. The 1620 packs *more computing power per cubic inch* than any other computer in its size range.

The Regression Analysis program is a good example. Suppose you want a fit for production purposes. If you employ more than two variables you probably have difficulty visualizing the representation of your data. If linearity is not the case, you must often guess blindly at a polynomial of high degree, accept or reject the fit with something approaching a sixth sense, and either try again or settle for the results you have.

The new Regression Analysis program lets you handle expressions containing up to *24 variables*. If you have the even more complicated task of handling many dependent variables, the program will generate regression coefficients with a maximum number of dependent variables not exceeding one-half the number of independent variables.

This program will also fit non-linear functions and hyper-surfaces. Compare this performance with that of any other computer in the 1620's price range.

A basic 1620 installation rents for just $1600 per month. For details, contact your local IBM Representative.

IBM's 1620 is a compact desk-size computer.

IBM®
DATA PROCESSING

No. 139 on Reader Service Card

NO CEILING ON LINE SUPPORT IDEAS

33,000 TYPES AND SIZES OF LINE SUPPORT CLAMPS, BLOCKS AND HARNESS STRAPS

For Aircraft, Missiles and Original Equipment of all kinds. Designs available for application in extreme environments... withstand jet engine heat or stratospheric cold... silicone impregnated, fiberglas cushioned, thermoflex, stainless steel. You name it... *ADEL* has it!

Build LINE SUPPORT *reliability* into your system.

Specify ADEL for quality in volume

COMPLETE CATALOG AVAILABLE UPON REQUEST

Reliability ADEL PRODUCTS DIVISION

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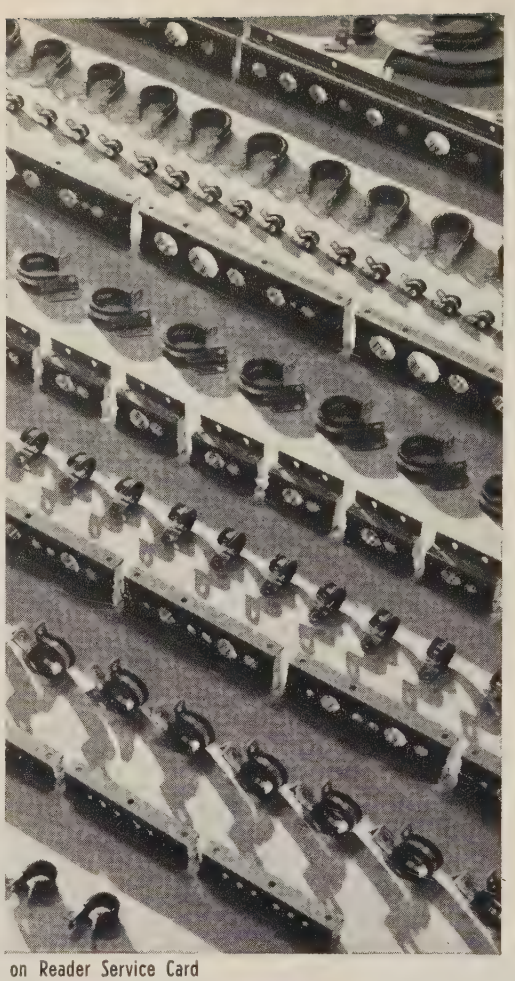


No. 182 on Reader Service Card

EQUIPMENT PREVIEW

COAXIAL ATTENUATOR provides high power

This fixed coaxial attenuator is said to feature high power performance, providing attenuation of 1.5 db ±0.1 db in the UHF range. It successfully accepts up to 200 watts of CW power, says **Merrimac Research & Development, Dept, SA, 517 Lyons Ave., Irvington, N.J.** Its dimensions are 10 in. x 1½ in. x 1½ in.

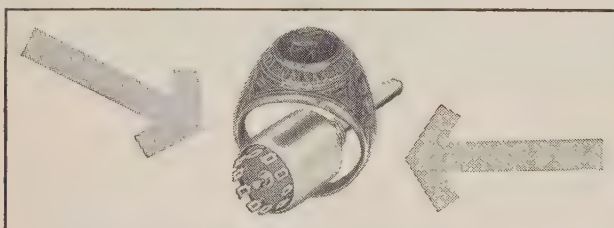
No. 327 on Reader Service Card

STAR TRACKER scans electronically

An all-electronic scanning star tracker has been developed for sources in the visible and near-infrared regions. The **ITT Astrionics Laboratory, Dept. S/A, 3700 East Pontiac St., Fort Wayne, Ind.,** reports that sources equivalent to a sixth-magnitude star can be tracked at a rate of one radian per second.

The tracking telescope contains an optical system, phototube, and electronic circuits. The start sensing element weighs two lb and occupies thirty-five cu in.

No. 328 on Reader Service Card

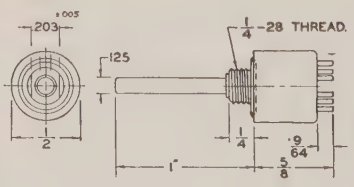


THE SMALLEST ROTARY SWITCH EVER MADE!

Daven's New Series G Sub-Miniature Switch, 1/2" Diameter!

A new sub-miniature rotary selector switch, developed by DAVEN, is specifically suited for application in missiles, aircraft, handy talkies, field pack sets, frog-man communication equipment, and all types of mobile apparatus. This explosion-proof, waterproof switch has the same reliability as its bigger brothers... but in a fraction of the space. It meets applicable military specifications on temperature, humidity, corrosion, vibration, acceleration, shock and immersion.

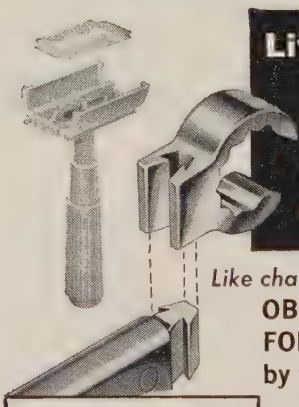
This unit is available as a single pole, 10 position switch and can be obtained with up to four poles on a single deck.



THE DAVEN CO.
LIVINGSTON, NEW JERSEY

Write today for comprehensive technical report on the new Series G Sub-Miniature Rotary Switch.

No. 183 on Reader Service Card



Livermont Adjustable TORQ-STOP WRENCHES with Interchangeable Handles and Heads

Like changing blades in a razor!

OBSOLESCENCE ENDED FOREVER — Thousands in use by the U.S. Armed Forces.

AUTHORIZED FACTORY DISTRIBUTORS

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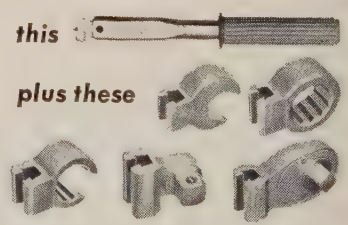

Yes, with a few Livermont Interchangeable Torque handles and wrench heads you can now accomplish nearly every torque requirement for years to come with only the purchase of additional inexpensive new heads.

NOTE: These wrenches may be preset to specific requirements, but can be readily reset by you to any torque value from 3 to 3000 inch pounds.

LOOK TO THE LEADER
RICHMONT, INC.
"THE HOME OF TORQUE"
922 So. Myrtle Avenue, Monrovia, Calif.

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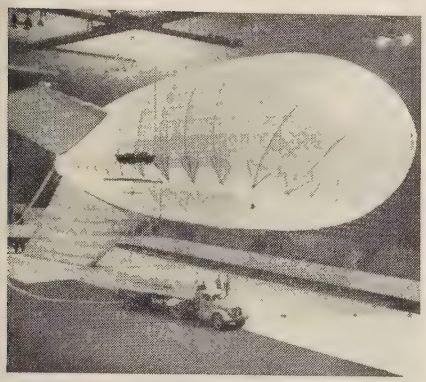
3M MATERIALS MEMO

News of materials for the aerospace industry – selected from the 27,000 products of the 3M Company



A NEAT BAG OF TRICKS

Even the best of magicians have to keep their audience in the dark to put their tricks over. There are no deep dark secrets or sleight of hand in our brand of magic. In fact, you'll see through it at a glance. The real magic is "in the bag"—if it's made of one of the "SCOTCHPAK" Brand series of transparent films. Whether your problems come in little packages—or loom as big as a "Skyhook" balloon, chances are that you'll find the answer in this product of our Industrial Tape Division.

"SCOTCHPAK" Brand Film is truly a hybrid in that it combines such a variety of desirable properties in one packaging medium. First there's the toughness of a polyester—(tensile strength as high as 10,000 lbs./sq. in., burst strength from 32 to 50 lbs./sq.in.). Then of course there's heat sealability to provide seals as tough as the film itself. All it takes is a pressure of 20-60 psi at a temperature of 300-400°F to do it. You can depend on "SCOTCHPAK" Brand Film for dimensional stability, too—all the way from —70°F to +240°F. Since there's no plasticizer to bleed out, it doesn't become brittle as it ages. Its low water vapor permeability and gas penetration, combined with chemical and solvent resistance, are definite pluses, too, from a packaging point of view. Critical parts can be sealed directly in oil or in special desiccant package constructions.

These same properties can be mighty important in balloon construction, too. And for special heavy duty applications, like air inflated buildings, "SCOTCHPAK" Film is made with nylon reinforcement (tensile strength =12,600 lbs./sq.in.). Can you use more data on "SCOTCHPAK" Film? Clip the coupon and receive the whole package.

WE'VE GOT A SYSTEM

It's not likely to help you make a killing on the ponies or clean up at the dice tables, but it's a cinch to work and save you money by cutting paperwork costs. Conceived and tenderly nurtured by our "Thermo-Fax" Copying Products group, this system is a whiz at numbers—numbers like 25 permanent white bond-weight copies from a single original and as little as 2¢ per copy.

Equally interesting is how the "Thermo-Fax" Brand Systems Papers work. There are two papers—"A" and "B". These together with any standard "Thermo-Fax" Copying Machine make up the whole "system". The process starts by typing, writing, printing, or drawing your data on the type A paper, just as you would ordinary stationery. Next, the type A sheet original is run through the "Thermo-Fax" Copying Machine with the white bond weight type B copy paper. Except for being able to repeat this step 5, 10 or even 25 times, that's all there is to it. This places a short-run reproduction system right in the hands of your secretary—or laboratory. No need to bring someone else into the act.

Other factors worth noting: The individual copies are all sharp and clear—look so much like originals, everyone gets a good copy. Remember too that the type A paper can be printed as one of your special forms or letterheads so headings and lines, etc., will also reproduce. It could even be used as a chart paper for original recording of data which can later be reproduced. Why not make this system a part of your operating scheme?

GET YOUR (kilo) CYCLES ON THE RIGHT TRACK

When handling of those kilocycles begins to be a vicious cycle and data processing operations jam up like Labor Day traffic, don't just grit your teeth. There is a way to get past the roadblock of conventional magnetic recorder/reproducer limitations. That way is the all new G-100 unit produced by our Mincom Division.

Setting a new standard in versatility and ease of operation, the G-100 can put your data on a clear track in a hurry. As a matter of fact, it offers you up to 14 tracks for information, plus a separate voice annotation track—all on a single modular rack, mind you. And it makes recording of either analog or FM information a real breeze. With equal ease and confidence, you may record static test information in the comfort of your own laboratory, or acquire data from dynamic operations high in the sky.

At a tape speed of 60 ips, the G-100 has a bandpass of 200 cps to 300 kc analog modules and dc to 20 kc with FM modules. A push-button selection of six speeds from 3¾ to 60 ips gives you a speed reduction ratio of 16 to 1 with no bothersome belt changes to plague your patience. At the lower speeds, the lower frequency response is extended to 50 cps, and all six speeds are phase-equalized to assure faithful reproduction.

Other plus features of the G-100 include greater dynamic range, a built-in monitor switcher, and built-in calibration so that you may preadjust the recorder to the incoming signal amplitude. And don't overlook Mincom's exclusive dc tape transport. Another premium of the G-100, it gives you freedom from fear of outside power fluctuations.

For more details about this attractive package, just check the box below.

3M Company, Missile Industry Liaison—Dept. VAA-91
St. Paul 6, Minn.
Please send more information on:

☐ "SCOTCHPAK" Brand Film ☐ G-100 Mincom Unit
☐ "THERMO-FAX" Copying Products
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CLAMPS by WITTEK

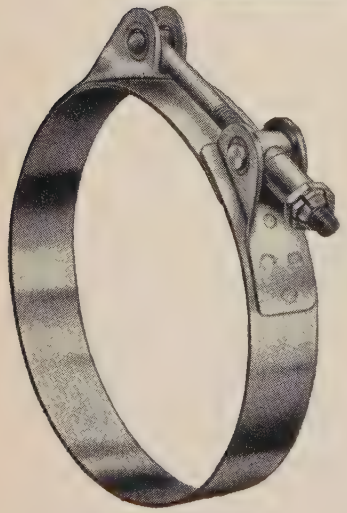
for the *Space-Age*

STAINLESS STEEL FLAT BAND CLAMPS

Complete range of sizes from 2¼" to 10" diameter

Quick-Latch Clamp—Series 10QL

Meets rigid military standards where easy installation and removal are important. The patented latch construction gives positive assurance against accidental disconnect. Basic materials and components meet MS requirements governing Part MS21920R.



T-Bolt Clamp—Series 10T

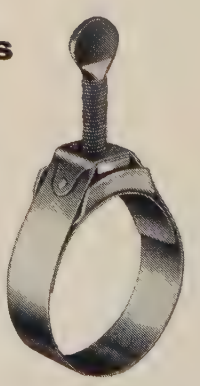
Same as 10QL but without patented quick-latch, and recommended for more permanent applications. Meets MS requirements governing Part MS21920.

STAINLESS STEEL AIRCRAFT CLAMPS

Complete range of sizes

Type AN737-TW (with shoe)

Type AN737-TWLS (without shoe)



Type AN737-RM (floating bridge)

Descriptive literature or recommendations for any clamping requirements upon request.

Quality Clamps for over a Quarter Century

WITTEK MANUFACTURING CO.

4368 West 24th Place, Chicago 23, Illinois

CLAMPS for Every Application

8825

PHOTOCELL for electro-optical controls

This photocell is said to offer unique and useful properties for many types of electro-optical control systems. It is a light-actuated PNPN silicon switch having a very high impedance, over 10 megohms, when off and a very low impedance, under 10 ohms, when triggered on by light, according to **Solid State Products, Inc., Dept. S/A, one Pingree St., Salem, Mass.** Its dimensions are 0.185 in. in diameter by 0.200 in. in length.

The unit can deliver up to 300 mA load current at up to 200 V with an efficiency exceeding 98 per cent. Applications include counting, sorting, power control, limit switching, programming, and optical logic control.

No. 329 on Reader Service Card

SOLID-STATE MODULE is microminiature

This microminiature module, called Bipco, is a built-in-place component in modular form. It features simple inputs and outputs which perform functions "normally requiring myriads of elements and connectors," according to **Electronic Tube Div., Burroughs Corp., Dept. S/A, P. O. Box 1226, Plainfield, N. J.** For first module to be made available is a binary coded decimal-to-decimal converter using the 4-2-2-1 code.

The multi-element components are simultaneously fabricated within a single device and placed in a predetermined pattern in such a manner as to facilitate complex internal connections, the company said. The processing of large numbers of semiconductor elements within a single unit and under identical conditions is said to reduce variations between individual elements to a minimum

No. 330 on Reader Service Card

MEMORY DRUM in 12-inch size

A twelve-inch model magnetic memory drum, weighing eighty lb, is announced by **Digital Development Corp., Dept. S/A, 7541 Eads Ave., La Jolla, Calif.** The 50-track, 300 kc drum operates at 3600 rpm with a capacity of 133 bits per in.

The unit measures 17 in. in diameter by 12 in. high, and has a 60 cycle, single phase, 110 volt motor for either 3600 or 1800 rpm, nominal. A molecular sieved dessicant reduces the unit's interior dewpoint to −65 deg F. A sealed unit, it can be supplied with inert gas to extend bearing life.

No. 331 on Reader Service Card

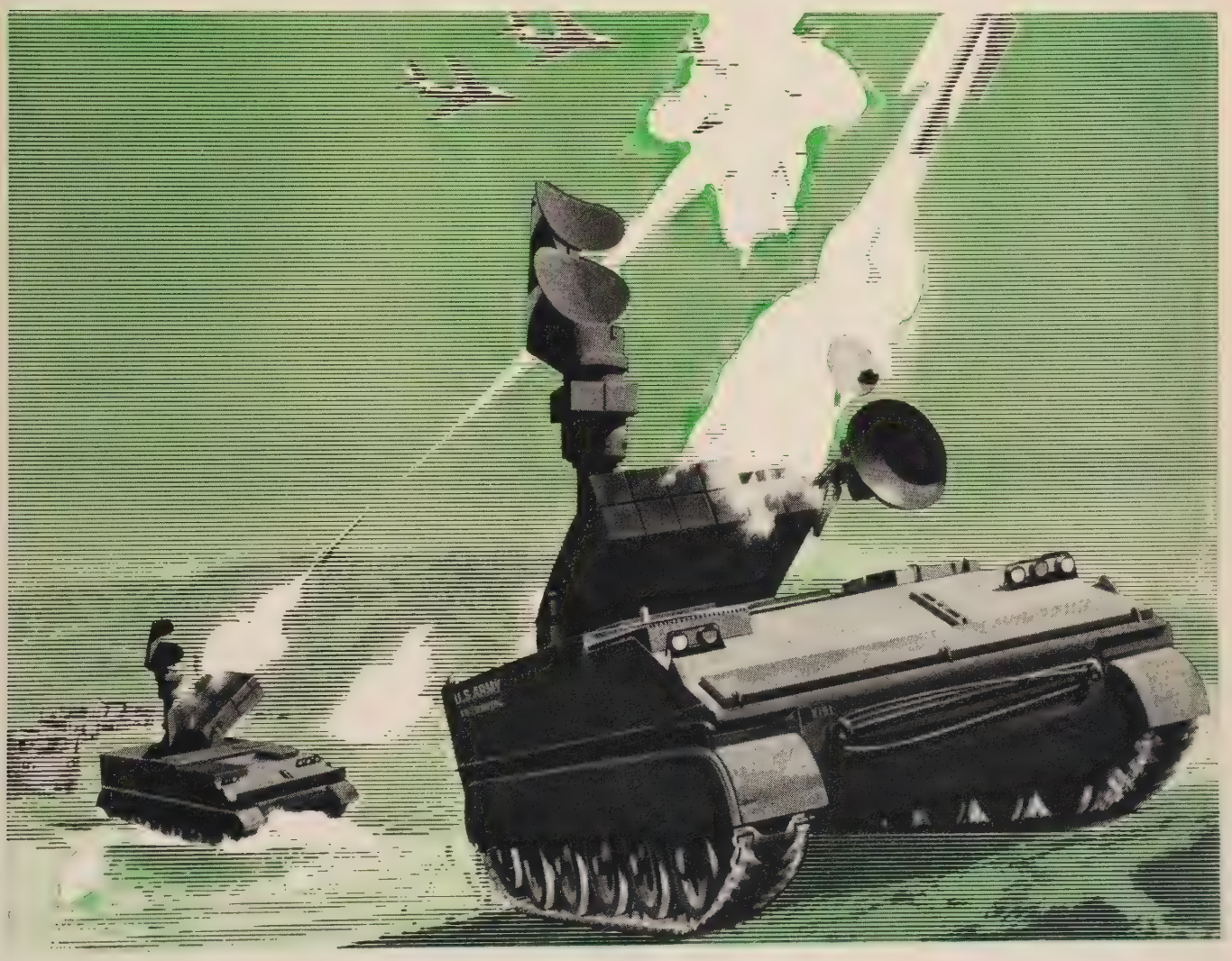
No. 186 on Reader Service Card

MAULER MOBILITY —BY FMC

SELF-CONTAINED WEAPONS SYSTEM

The striking power of the Army's Mauler automatic-firing air defense system, now in development, will be extended by its exceptional *mobility*—engineered and built by FMC. Working closely with Convair/Pomona, Convair Division of General Dynamics Corporation, and ARGMA, an element of the U. S. Army Ordnance Missile Command, FMC is responsible for (1) the tracked carrier, adapted from our standardized M113 vehicle, and (2) the launching pod assembly and the auxiliary power unit. Result: a self-contained weapons system, tracked for on-road or off-road mobility in any terrain.

When mobility is the question, call in FMC, since 1941, a leading designer and builder of military standardized vehicles.



For further information, write on company letterhead to Preliminary Design Engineering Dept., FMC Ordnance Division, P.O. Box 367, San Jose, California. Phone: CYpress 4-8124.

FMC CORPORATION
(Formerly Food Machinery and Chemical Corporation)
ORDNANCE DIVISION
1105 Coleman Avenue, San Jose, California

PUTTING IDEAS TO WORK FOR NATIONAL DEFENSE

No. 187 on Reader Service Card

COAXIAL RELAY for all-weather use

This all-weather coaxial relay was designed as an outdoor unit. It is a one-pole, two-throw unit of gold anodized aluminum construction and is lightweight, according to **Bay-Roy Electronics, Inc., Dept. S/A, P.O. Box 7503, Cleveland 30, Ohio.** The frequency range is 0-225 mc/sec.

The relay is available with a variety of RF connectors, such as type "N," "BNC," etc.

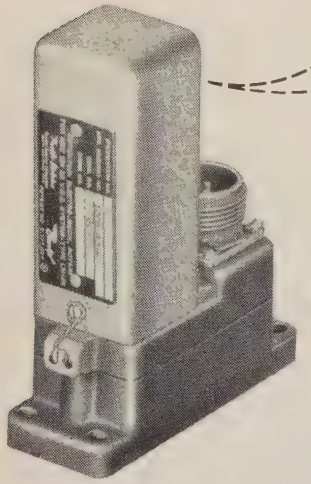
No. 332 on Reader Service Card

SILICON TRANSISTOR gives field-effect

A silicon field-effect transistor, which is a three terminal amplifying device with "practically infinite input and output impedances," has been announced by **Crystalonics, Inc., Dept. S/A, Cambridge, Mass.** It is said to be about ten times more resistant to atomic radiation than the conventional type. Amplifying action occurs in the bulk of silicon and is completely removed from the surface.

No. 333 on Reader Service Card

BENDIX-PACIFIC
SERIES 128
ROTARY
ACTUATORS



FOR ENGINE AND OTHER OPEN AND CLOSED LOOP CONTROL SYSTEMS IN
MISSILES AND AIRCRAFT

★ Outstanding power-to-weight ratio.
★ 100 lb. inches of torque with 70 watts output power. Weight 16 oz.
★ Flexibility of application with wide variety of output speeds and positions.

Contact Bendix-Pacific when your design requires—
ACTUATORS
Geneva-Loc • Conventional Rotary Linear • High-Response • Safe & Arm
TIMERS
Sequential Programming Repeat Cycle • Adjustable

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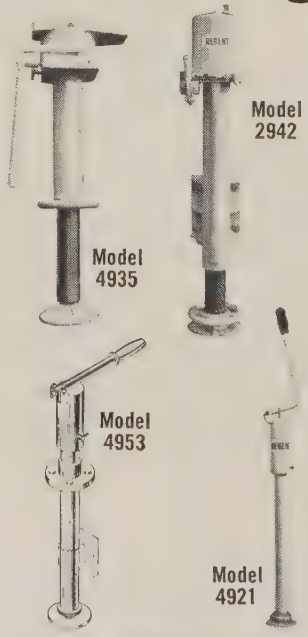
Quick-acting . . . Self-retracting



Fast acting (six-times faster!), Regent hydraulic leveling jacks are easy to use . . . dependable even under most difficult operating conditions. Whether used at forward-field or fixed-base, Regents are sure-footed, virtually effortless. Step, and the ram descends silently and quickly — locking the footpad to the ground. Just a few quick movements of the hand-pump handle, and the trailer lifts off the ground, locks in place. Then — just flick the valve and the ram retracts to lower the trailer to the ground, then automatically continues on to fully-closed position. Compact Regents are available in standard units from 2 to 50 tons capacity. Or we can engineer to your special requirements.

Hydraulic leveling jacks for aircraft and missile transport trailers and missile launchers.

MODEL NO.	4953	4935	2935R	2942	4973
Vertical Capacity (tons)	2	5	5	5	3
Min. Closed Height (in.)	23½	22	26	32	22¾
Hydraulic Lift (in.)	10	10	10	15	14¾
Working Pressure (psi)	4650	1670	2020	1670	1000
Net Weight (lbs.)	15	48	63	72	—

REGENT

REGENT JACK MANUFACTURING CO., INC.
11905 Regentview Avenue
Downey, California • SPruce 3-0103

No. 189 on Reader Service Card

PORTABLE VHF ANTENNA for tracking and telemetry

Air transportable, this Model 420A dual-polarized antenna is designed for missile tracking. **Avien, Inc., Dept. A/A, 58-15 Northern Blvd., Woodside 77, N.Y.** claims that the 420A is lighter, smaller, and less expensive than conventional array type antennas being used for missile tracking. The 420A operates in the standard frequency range of 215-260 mc with a gain of 18 db minimum over the band.

This model antenna is 8x8x6 ft and weighs 250 lb. An alternate design is available that collapses to five ft square by two ft deep without disassembly.

No. 334 on Reader Service Card

AIRBORNE DATA SYSTEM records 31 inputs

This airborne data recording system monitors, converts, and records up to 31 analog inputs in digital magnetic tape form for subsequent high speed computer processing on the ground. The all solid-state modular design is of plug-in printed circuit card construction, says **Monitor Systems, Inc., Dept. S/A, Fort Washington Industrial Park, Fort Washington, Pa.** It was designed specifically to speed investigation and analysis of meteorological phenomena.

Major components are a 36-channel dual transistorized multiplexer, a transistorized analog-to-digital converter, and a four-speed, 16-channel magnetic tape recording unit.

No. 335 on Reader Service Card

X-BAND TUBE is small and light

An X-band tube measuring 12 in. in overall length and weighing three lb, eight oz, has been announced by the **Sperry Rand Corp., Electronic Tube Div., Dept. S/A, Gainesville, Fla.** The STX-265 rated power output is 1 watt minimum, with small signal gain of 30 db nominal. Input-output isolation is 75 db minimum.

The unit will withstand vibrations of 10-gs at 5-2000 cps, shock toleration is 15 gs for 10 ms, and performance is normal to altitudes of 70,000 feet. The rugged metal-ceramic construction, miniaturized envelope and temperature compensation of the traveling wave tube make it suitable for applications in broadband or multiple frequency systems, noise generators, and millimicrosecond switching devices.

No. 336 on Reader Service Card

10426-CH

How *critical* can you be in your selection of a fastener for a special application . . . especially when extreme accuracy, reliability and consistent performance are specifications. For over thirty years, Chandler has been producing special fasteners and standard cap screws and bolts that meet these demanding requirements.

If you have a special fastener problem . . . here's what you can expect from Chandler. *Into the design* of your special fastener goes the knowledge of expert Chandler engineers . . . careful attention to detail and exhaustive testing to meet critical standards . . . advanced production methods to assure on-time delivery . . . RESULT . . . a precise fastener, custom-tailored and mass-produced at the most favorable cost.

Next time . . . Check with Chandler . . . FIRST.

Write today for your Chandler catalog.

CP

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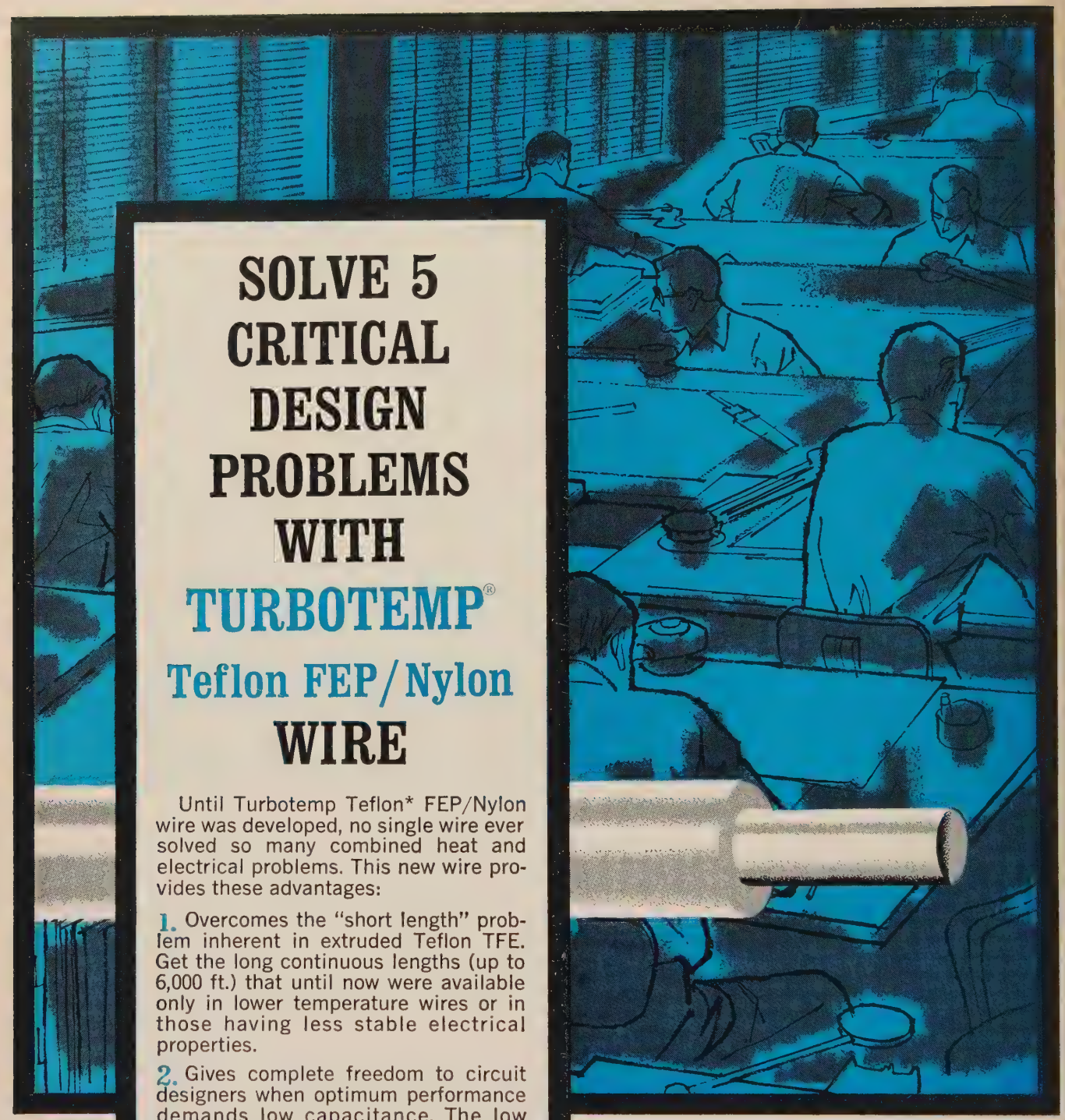


SOLVE 5 CRITICAL DESIGN PROBLEMS WITH TURBOTEMP®

Teflon FEP/Nylon WIRE

Until Turbotemp Teflon* FEP/Nylon wire was developed, no single wire ever solved so many combined heat and electrical problems. This new wire provides these advantages:

1. Overcomes the "short length" problem inherent in extruded Teflon TFE. Get the long continuous lengths (up to 6,000 ft.) that until now were available only in lower temperature wires or in those having less stable electrical properties.

2. Gives complete freedom to circuit designers when optimum performance demands low capacitance. The low dielectric constant of FEP/nylon shows minimum change over a wide range of frequency and temperature.

3. Provides utmost reliability to automatic wire wrap terminations. Of all conventional plastics or combinations tested, FEP/nylon has the best cut through resistance on wire wrap pins.

4. Is suitable for continuous operation up to 120°C, an important consideration if computers are for military use.

5. Meets flammability requirements of both MIL-W-16878 and U.L. Appliance Wire.

* DUPONT REG. T. M.

BRAND REX

DIVISION OF

American ENKA Corporation

DEPT. W, 41 SUDBURY ROAD, CONCORD, MASSACHUSETTS
TELEPHONE: EMERSON 9-9630

WRITE FOR COMPLETE DATA!

No. 191 on Reader Service Card

DIGITAL CLOCK for data processing

A digital clock, designed as a long-duration data timer or as a date-time source for data processing equipment, has been announced by **Electro-Logic Corp., Dept. S/A, 515 Boccaccio Ave., Venice, Calif.** A binary coded output of the day, hour, and minute is provided by contact closures permitting use of any logic voltage level from a data system.

Stepping switches make the date and time continuously and simultaneously available. The clock is without tubes or transistors.

No. 337 on Reader Service Card

CENTRIFUGAL FAN for electronic cooling

This compact, single inlet, single wheel centrifugal fan is designed for cooling and pressurizing requirements in the electronic and control fields.

With scroll widths ranging from 3 7/8 in. to 9 1/2 in., the units have air deliveries from 45 to 325 CFM over a wide pressure range, says **Propellair Div., Ronnins & Myers, Inc., Dept. S/A, Springfield, Ohio.** A variety of special mounting brackets and filter cabinets are available.

No. 338 on Reader Service Card

FLEXIBLE WAVEGUIDES for L-Band use

High-pressure flexible waveguides using 45 lb pressure for L-band, are now available for high-power radar. The waveguides are available in a wide variety of flange combinations for operation at 50,000 watts CW and 25 MW peak power.

According to **Technicraft Div., Electronic Specialty Co., Dept. S/A, 115 Waterbury, Rd., Thomaston, Conn.,** these high-pressure units, which were tested at the M.I.T. Lincoln Laboratories, are in production for the Nike-Zeus anti-missile program.

No. 339 on Reader Service Card

PREAMPLIFIER uses nuvistor tubes

This IF71 preamplifier features minimal power drain provided by the use of nuvistor tubes. It is small in size and weight, says **Lel, Inc., Dept. S/A, 75 Akron St., Copiague, L. I., N. Y.** The series has 8 mc bandwidth, 30 db gain, and a noise figure as low as 1.5 db.

Intended for use with microwave mixers, the input is designed to operate from a 300-ohm, 22-mmfd source.

No. 340 on Reader Service Card

THIN-FILM SYSTEM for microcircuits

This production model EB-101 vacuum system is for the manufacture of thin-film microcircuits, conductors, and multiple resistors. It is the "first integrated equipment" to be made available, says **GVC Electron Heating Corp., Dept. S/A, Medford, Mass.** The thin-film elements produced meet standard tolerances.

Detailed operating instructions and customer-training services are provided by the company.

No. 341 on Reader Service Card

GUIDANCE DECODER for missiles

A highly ruggedized, 100-g shock summary network has been developed by **Essex Electronics Div., Nytronics, Inc., Dept. S/A, 550 Springfield Av., Berkeley Hts., N. J.** The device is said to be, in effect, a distributed constant delay line.

The critical component, housed in a die-cast aluminum case, has a total delay of 1.6 ± 0.026 usec and a tap delay of 0.8 ± 0.013 usec. Impedance is 600 ohms ± 10 per cent and operation temperatures vary from −65 to +165 deg F.

No. 342 on Reader Service Card

CIRCUIT ELEMENTS are integrated

Fabrication of various integrated circuit components, i.e., circuit elements associated with a single function mounted in a single enclosure has been announced by **Philco Corp., Lansdale Div., Dept. S/A, Lansdale, Pa.** Diode arrays of three to eight diodes per pac have been fabricated.

The diodes used are low conductance, very fast switching silicon computer devices with reverse recovery switching speeds in the five nanosecond range, the company says.

No. 343 on Reader Service Card

TINY TRANSFORMERS are transistorized

Two miniaturized transistor transformers, called "Buds" and "Mites", have been developed by **Decco, Inc., Dept. S/A, 2025 Farrington, Dallas, Texas.** The units are encased in drawn steel cans with nickel alloy leads on standard 0.1-in. spacings for rapid printed circuit board mounting.

The "Bud" configuration is 5/16-in high and the "Mite" is 3/8 in. in diameter. Forty-two designs in either style are available as standard units.

No. 344 on Reader Service Card

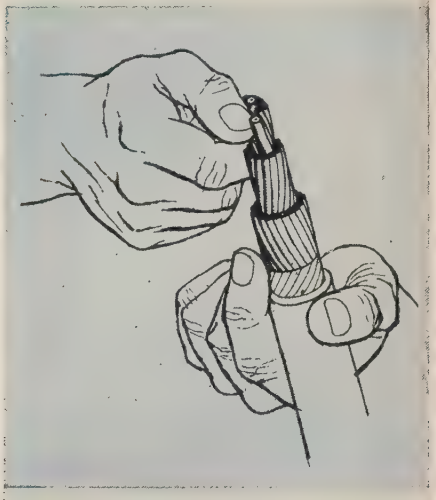
BRAND-REX CABLEMANSHIP

The Big Difference In MIL-C-13777B Neoprene Jacketed Cables!

Missile men, especially, know the advantages of Neoprene jacketed cables . . . low temperature flexibility, abrasion resistance and resiliency. And missile men who are also cablemen know it pays at the count-down to count on Brand-Rex Cablemanship! And you should too.

There's more to the absolute reliability of Brand-Rex cables than just rigid adherence to specifications. Brand-Rex Cablemanship combines technology, skill, broad cable engineering services, production capability of three coast-to-coast plants and technical field service . . . all delivered by a tightly-knit organization backed by the vast resources of the American Enka Corporation.

Whatever your requirements for wire or cable, regardless of the rigidity of your specifications for conductors, layup patterns, insulation materials, shielding or armoring, you can count on the Cablemanship of Brand-Rex.



Write for samples and information today!

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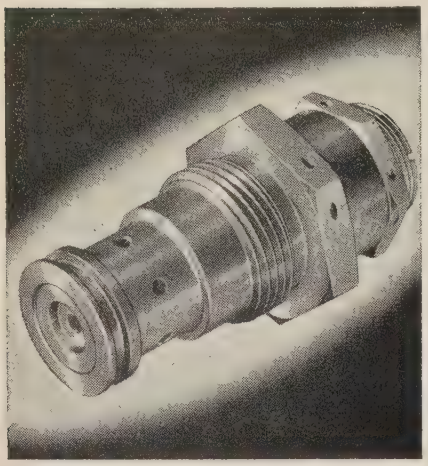
No. 192 on Reader Service Card

Another Fluid Regulators Achievement



NEW Cartridge Flow Regulator

- Maintains constant flow to the system when pump output varies
- Assures constant flow under varying upstream and downstream pressures

Developed and produced for use in multi-valve manifold, this small, lightweight valve eliminated connectors, fittings and lines. It reduced leakage points and weight, and permitted system design engineers greater design freedom.

Designed in close cooperation with the customer's engineering department, this valve illustrates the capabilities of Fluid Regulators to meet critical flow, size and weight requirements. Contact us today, for prompt action on your specific problems.

SPECIFICATIONS

- Regulated Flow: 0.1 gpm to 6.5 gpm with various combinations of springs and orifices. Factory Set—with limited field adjustment available.
- Regulation: ±10% for flows 0.1 to 1.5 gpm
  ± 5% for flows 1.5 to 6.5 gpm
- Pressure Drop: 25 psi at high flows — 50 psi at low flows.
- System Pressure: to 2,000 psi
- Proof Pressure: 3,000 psi
- Burst Pressure: 5,000 psi
- Weight: 4 oz.
- Temperature: —65° F. to +275° F.
- Fluids: any fluid compatible with materials.
- Materials: aluminum alloy and stainless steel.
- Finishes: aluminum alloy parts hard-coated—stainless steel passivated.
- Designed to meet MIL-V-8566
- These specifications may be changed to meet your specific requirements.

Fluid Regulators CORPORATION

313 GILLETTE STREET • PAINESVILLE, OHIO
ELmwood 2-3319

No. 193 on Reader Service Card

EQUIPMENT PREVIEW

COOLING SYSTEM for airborne electronics

A patented constant torque magnetic coupling is used to power the blower in this type 200A cooler. According to **Eastern Industries, Inc., Dept. S/A, 100 Skiff St., Hamden 14, Conn.**, the design also contains an unusually compact pumping manifold. The constant torque coupling allows the impeller to deliver an essentially constant mass of air, regardless of altitude.

At sea level, the cooling system requires 380 W input from 115/208 V, 400 cps, three-phase aircraft power supply. The hydraulic cooling pack, which is 7x7x5 in., weighs 9 lb. The radiator blower assembly measures 6⅛x8¾x3¼ in. and weighs 8 lb.

No. 345 on Reader Service Card

TRANSISTOR HEAT SINK cools by natural convection

This natural convection heat sink has a thermal resistance of 1.3 deg C per watt. According to **Astro Dynamics, Inc., Dept. S/A, 200 Sixth St., Cambridge, 42, Mass.**, Model 2502 has more surface area and takes up less space than conventional designs. It is said to have 47 per cent lower thermal resistance.

Model 2502 measures 4x3x1.28 in. and weighs 0.4 lb. It has a standard 1-¼-inch-diameter recess for mounting transistors. Standard models come in black anodized finish, with four corner holes for heat sink mounting. Custom models are also available.

No. 346 on Reader Service Card

RECORDER/REPRODUCER features wide range

This recorder/reproducer, G-100, has a bandpass at 60 ips of 200 cps to 300 kc using analog modules and DC to 20 kc using FM modules. Wide dynamic range and all-transistorized electronics are highlights, says **Mincom Div., Minnesota Mining and Mfg. Co., Dept. S/A, 2049 S. Barrington Ave., Los Angeles 25, Calif.** The single rack can accommodate up to 14 tracks of information plus a separate voice annotation track.

The system offers six standard speeds from 3¾ to 60 ips. All speeds are phase-equalized. Other features are a built-in signal monitoring switcher and built-in calibration.

No. 347 on Reader Service Card

Casting Engineers Light, Super-Strong Investment Castings

This strong, thin-walled investment cast hinge is the key part of a special "droop" mechanism that brakes supersonic Navy F8U Crusader jets for slow-speed landings. Casting Engineers produce the complex part for ⅓ the cost of machined hinges, with superior results:

Specifications

Material	Type 410 stainless steel
Tensile Strength	Over 180,000 psi
Wall Thickness	.125" tapered to .090"
Part Length	6"
Flatness	.015" TIR
Inspection	100% X-ray and magnaflux

Casting Engineers has demonstrated its ability to cast precision components in over 100 alloys—steel, copper-base, aluminum and "exotic" metals.

Whether your application requires our high-volume MINICAST process for relatively small parts, or the newer MONOCAST ceramic shell technique for larger pieces, Casting Engineers guarantees maximum production efficiency at lower cost.

A competent staff of design, mechanical and metallurgical specialists makes Casting Engineers your best single supply source for castings for any application.

Write today for free application brochure and technical data for designers!

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No. 194 on Reader Service Card

CRYSTAL FILTERS for 10 kc to 30 mc

These crystal filters cover a broad range of applications in single-sideband, telemetering, missile-guidance, radar and navigation equipment. Available units are over the 10 kc to 30 mc frequency range, says **Collins Radio Co., Dept. S/A, 19700 San Joaquin Rd., Newport, Calif.** One of the units is a 5 mc filter in a thumb-size ⅜-cu in. case.

The filters are said to provide high selectivity, as well as being compact bandpass units for the stated frequency range.

No. 348 on Reader Service Card

VIDEO LOG AMPLIFIER fully transistorized

A logarithmic video amplifier which can be used with a crystal detector mount to have a 60-db dynamic range over a bandwidth of 4 mc has been announced by **W. L. Maxson Corp., Dept. S/A, 475 Tenth Ave., New York 18, N.Y.**

Maxson says that a separate stage feed-back permits shaping transfer characteristics. A pair of the LVT-1 amplifiers matched to within ±1.5 db can be supplied as a special item.

No. 349 on Reader Service Card

SUPER-POWER TUBE for long-range radar

A ceramic-metal super-power tube for use as a plate-pulsed RF power amplifier in long-range search radar and particle accelerator service has been announced by the **Electron Tube Div., Radio Corp. of America, Dept. S/A, Rockefeller Plaza, New York 20, N.Y.** It can also be used where high peak power output is needed.

Full ratings may be applied up to 300 mc. At 250 mc, the tube can provide 5 Mw of useful peak power output at a duty factor of 0.06 and a pulse duration of 2000 usec.

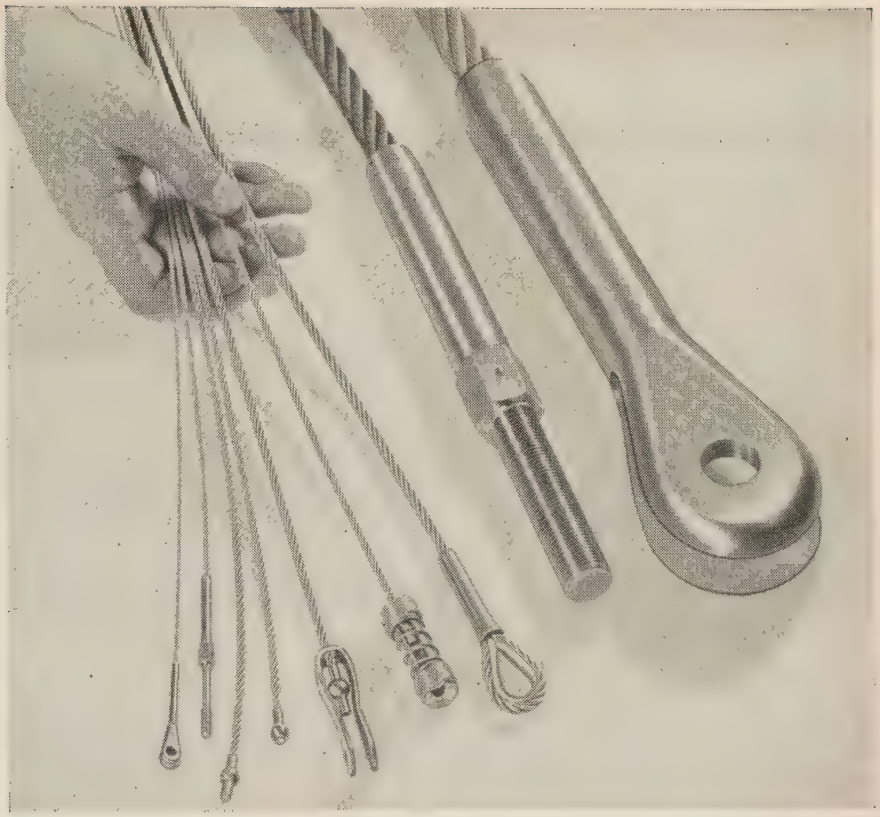
No. 350 on Reader Service Card

RECEIVER ASSEMBLIES are matched

These Series 40 amplifiers provide matched sets of equipment for microwave receiver prototype or production runs. A basic group of three units is available, says **Lel, Inc., Dept. S/A, 75 Akron St., Copiague, L. I., N. Y.** The units comprise a preamplifier, main IF amplifier, and AFC assembly.

Typical specifications include: IF frequency—60 mc, input from balanced mixer, output video cathode follower, bandwidth—4 mc, combined preamplifier, main amplifier gain—130 db.

No. 351 on Reader Service Card



Tru-Loc Swaged Aircraft Fittings
guaranteed free from defects...

Tru-Loc aircraft fittings are guaranteed three ways—they conform to specified dimensions; they hold to the minimum rated breaking strengths of the cables to which they are swaged; and they are free from deformation, splits and internal cracks. With Tru-Loc swaged fittings you also get:

Widest range of sizes • Tru-Loc fittings are available for cables ranging from 1/16″ to 2½″ diameters.

Types for every application • Sleeve-type, ball-type, ball-with-strap, center-pull loop fittings, "*Quickies*" for instant connect and disconnect—all of these fittings were originated by American Chain & Cable Company, Inc. Special fittings can be designed as required.

"NO-MAG" CABLES GIVE BETTER CORROSION-RESISTANCE THAN STAINLESS STEEL "No-Mag" cable is non-magnetic, won't interfere with instrument operation. In corrosion-resistance and thermal characteristics, it is superior to standard stainless steel. "No-Mag" aircraft cables also offer high fatigue and abrasion resistance, are available in a complete range of sizes in all the standard aircraft constructions.

GET THE COMPLETE STORY *on ACCO products for the aircraft industry*
Write to the Detroit Office

ACCO **TRU-LOC FITTINGS**

TRADE MARK

Automotive and Aircraft Division
American Chain & Cable Company, Inc.
601-T Stephenson Bldg., Detroit 2
6800-T East Acco St., Los Angeles 22 • 929-T Connecticut Ave., Bridgeport 2, Conn.

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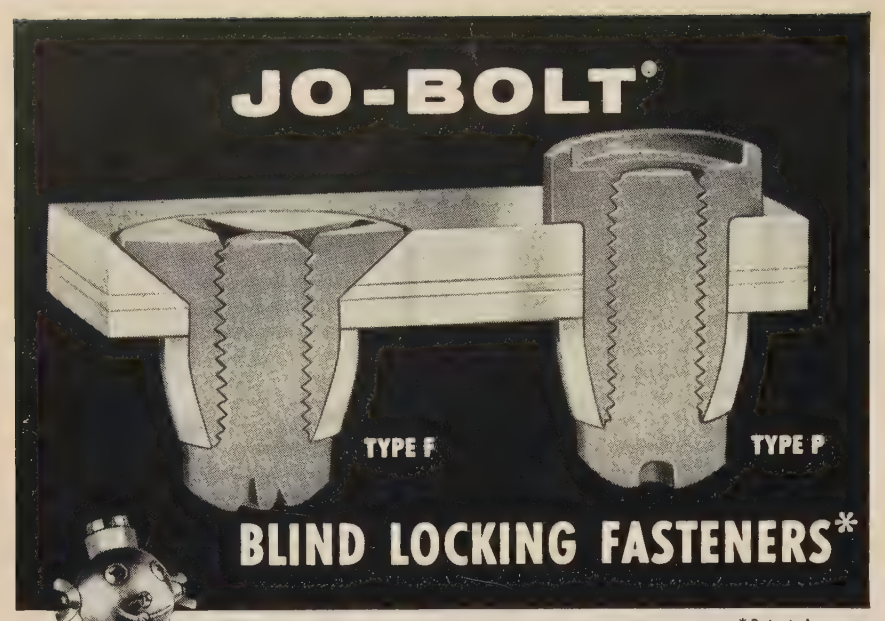
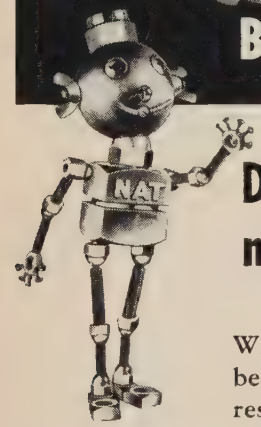


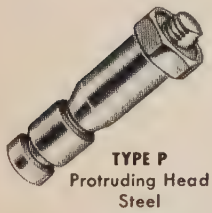
* Patented



DO IT BETTER · DO IT FASTER in missile/aircraft frame assembly

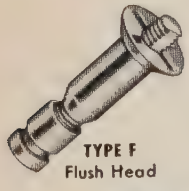
What happens in JO-BOLT Fastener installations can be seen at a glance, in the cross section above. The resulting clamp-up of sheets and structural members is tight and positive, 100% effective.

That's highly important . . . but not even the half of it. First, consider this . . . JO-BOLTS® are high-strength structural fasteners, typically providing: shear strength of 95,000 psi min. in steel types; 85% AN Bolt tensile strength in #10 and ¼" diameters; vibration resistance superior to bolts with lock nuts.



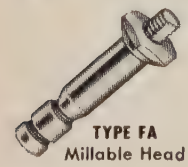
TYPE P
Protruding Head
Steel

Second, JO-BOLT Fasteners are lightweight and compact, allow savings in fastener weights averaging 50% or higher, often permit use of narrower and lighter substructures.



TYPE F
Flush Head

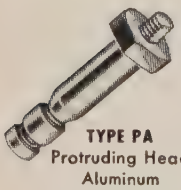
Third, JO-BOLT Fasteners can always be installed by one man from one side of the work . . . eliminating most common access and clearance problems.



TYPE FA
Millable Head

Finally, JO-BOLT Fasteners are foolproof and fast, can be popped into holes prepared and aligned for them, and driven to grip inside of seconds, always resulting in high-quality work, uniform and unmarred, regardless of worker skill.

They are so good, in fact, at fastening better and faster that they've been preferred and specified in practically all high-performance aircraft ever since introduction.



TYPE PA
Protruding Head
Aluminum

Write for illustrated booklet J 59. It lists specifications for all types, tells about A 286 Hi-Temp and other special JO-BOLT Fasteners.

National PRODUCTS

THE NATIONAL SCREW & MFG. COMPANY
CLEVELAND 4, OHIO
California Division, Los Angeles 22

MICA CAPACITOR NETWORK has precise output

This five-capacitor bank network can deliver 0.125 mfd with a one per cent tolerance. An incremental increase of 0.0005 mfd in 16 uniform steps for a total capacity of 0.1325 mfd is also possible, says **Cornell-Dubilier Electronics Div., Dept. S/A, 55 Cromwell St., Providence, R.I.** The assembly shown here is 1.75 in. in diameter and 0.19 in. thick.

All sections of the network will perform reliably over a temperature range of —55 to +85 deg C, says the company. Such operation is assured with an applied AC voltage of 50 V and 400 cycles.

No. 352 on Reader Service Card

PHOTOCELL has high sensitivity

This photocell has over 1 megohm resistance in darkenss and a broad response to visible light. The **Pioneer Electric & Research Corp., Dept. S/A, 743 Circle Ave., Forest Park, Ill.,** says that at illumination levels of 1 to 50 foot-candles, the photocell can operate a relay that requires up to 10 ma for operation.

The CDS-9 cell is non-polar and may be used on ac or dc. It has a power dissipation rating of ½ watt continuous and 2 watts for one minute. Maximum voltage is 500 dc or 350 rms ac. In its hermetically sealed case, it has a diameter of about **1.25** inches.

No. 353 on Reader Service Card

S-BAND ANTENNA is vertically polarized

This S-band antenna is vertically polarized. The Model 3001 has been designed for use in transmitting from an aircraft or as a ground beacon when used over a ground screen, says **Adams-Russel Co., Inc., Dept. S/A, 200 Sixth St., Cambridge 42, Mass.** The unit is completely sealed and contains an internal silica-gel reservoir.

The electrical characteristics are: Vertical polarization; 500 W CW power rating; 1.5 max. VSWR; 2400-3600 mc. bandwidth; 10 db gain in elevation, relative to isotropic and omnidirectional pattern in azimuth.

No. 354 on Reader Service Card

No. 196 on Reader Service Card

RADIO SYSTEM for 7125-7750 mc

This broadband microwave radio system, Type 74B, is for operation at any frequency in the 7125-7750 mc government band. All power needs in the terminals are met with fully regulated DC voltages from power supplies that are insensitive to frequency variations or power surges, according to **Lenkurt Electric Co., Dept. 716 S/A, San Carlos, Calif.** It can be equipped for either space or frequency diversity.

Standard built-in transmitter stability is ±0.02 per cent. Transmitter klystron output is one watt.

No. 355 on Reader Service Card

RF FILTERS WITH small connectors

RF filters equipped with special fittings to accept any of the common subminiature connectors have been announced by **Telonic Engineering Co., Dept. S/A, Laguna Beach, Calif.** Both bandpass and low-pass types are designed for use in missiles, ground support systems, and telemetering equipment.

Consisting of two, three, or four sections, the filters may be obtained with bandpasses from 2.5 to 25 per cent over 200-2000 mc frequency range. The low-pass types are available with any cut-off frequency from 200-2000 mc at 5-mc increments.

No. 356 on Reader Service Card

SILICON TRANSISTORS are tiny, double-ended

These double-ended subminiature silicon NPN transistors are electrically welded and hermetically sealed. They are capable of dissipating 400 mW at 25 deg C, according to **Raytheon Co., Dept. S/A, Lexington 73, Mass.** They are designed for use in ultra-compact circuitry.

When used in conjunction with their single-ended counterparts, the company says, unique mechanical requirements can be met. Other mounting possibilities include single and multiple-board configurations, feedthrough construction, welded assemblies and special assembly modifications such as jump-wiring and isolating inputs from outputs.

No. 357 on Reader Service Card

Typical profiles of Edgewater Rolled Steel Rings

HERE'S AN IDEA TO HELP REDUCE "profit squeeze"

Buy rings that are formed so close to finished shape and dimensions that very little machining will be needed. The result—less labor, less scrap loss, lower overall cost.

Edgewater rings are forged from solid blocks of steel, and rolled by a powerful ring-rolling mill to required cross-section shapes (see typical profiles above). Close tolerances minimize finishing operations.

Edgewater rolled steel rings are of uniform quality, strong and tough. Diameters: from 5 to 145 inches. Send drawings for recommendations and prices.

INTERESTING description of the ring-rolling process is given in this brochure, **Edgewater Rolled Steel Rings.** We will be glad to send you a copy.

EDGEWATER STEEL COMPANY

P. O. Box 478, Dept. SA, Pittsburgh 30, Pa.

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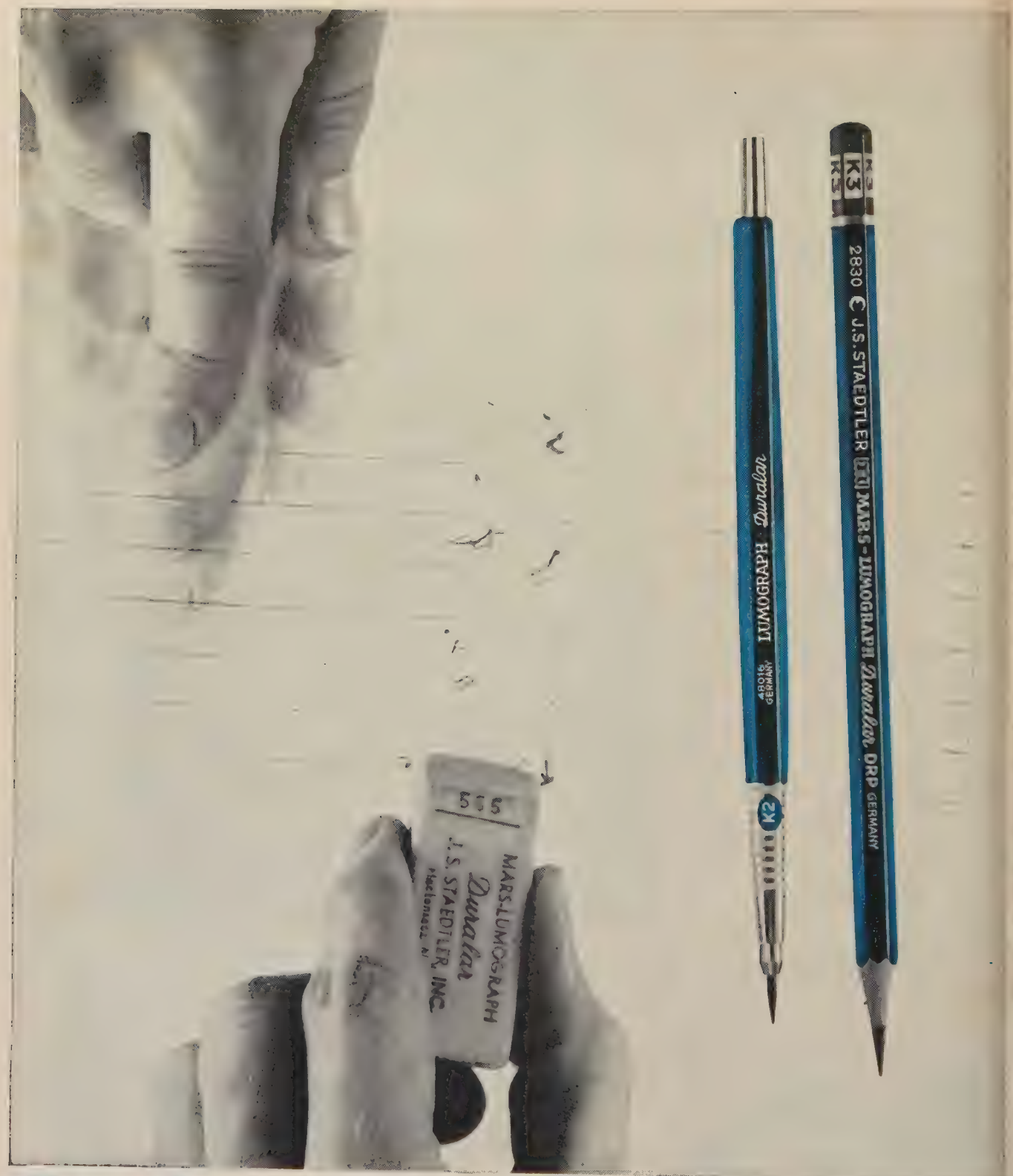


Mars products are available at better engineering and drafting material suppliers everywhere

Duralar:

WON'T SMEAR ON MYLAR - ERASES ON MYLAR

Specifically designed to work perfectly on matte-surface drafting film of Mylar®, Duralar is the newest in the complete line of Mars fine drafting products. All are imported from West Germany and are made to meet the highest professional standards. Shown: Mars-Lumograph Duralar pencil and lead—available in five special degrees, K1 to K5; Mars-Duralar Technico with adjustable Duralar degree indicator; Duralar eraser.

® T.M. for duPONT's Polyester film.

the pencil that's as good as it looks **MARS**

J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

No. 198 on Reader Service Card

I-materials & production equipment

FASTENERS — A special report for users of high-strength fasteners is offered by **Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa.** The SPS Laboratories Report No. 495 gives 10 recent examples of negligent practices in design and specification, procurement, fabrication, and inspection of fasteners, with recommendations for correction.

No. 359 on Reader Service Card

SECONDARY MACHINING—Bulletin No. 61 from **Standard Tool & Mfg. Co., Dept. S/A, Lyndhurst, N.J.**, describes the company's new multiple secondary operation machine, the MSO. Illustrated with photographs and mechanical drawings, it lists typical secondary machining operations which the MSO is capable of performing, and describes the machine's capacities, specifications, and accessory equipment.

No. 360 on Reader Service Card

INSERTS AND STUDS—A 28-page revised catalog on Keenserts threaded inserts and studs is now available from **Newton Insert Co., Dept. S/A, 6500 Avalon Blvd., Los Angeles, Calif.** The one-piece construction of Keenserts is described in detail. Advantages of different types are itemized. Complete removal and installation instructions are also included.

No. 361 on Reader Service Card

HIGH VACUUM EQUIPMENT—An illustrated booklet on high vacuum components and equipment is offered by **NRC Equipment Corp., Dept. S/A, 160 Charlemont St., Newton 61, Mass.**, a subsidiary of National Research Corp. Among the items presented are diffusion and mechanical pumps and accessories, vacuum coaters, crystal growing furnaces, vacuum furnaces, electron beam welders, and altitude chambers.

No. 362 on Reader Service Card

DIAPHRAGMS—Elastomer fabric diaphragms are described in a four-page brochure which has been issued by **Diaphragm Industries, Inc., Dept. S/A, 102 Rantoul Street, Beverly, Mass.** Long stroke, rolling pre-convoluted and molded convolution diaphragms are described and illustrated in the brochure. A comprehensive design worksheet is included to facilitate inquiries.

No. 363 on Reader Service Card

CYLINDER ACCESSORIES — A reference bulletin from **Hannifin Co., Dept. S/A, 501 S. Wolf Rd., Des Plaines, Ill.**, provides for quick identification of mounting accessories for square-type, industrial hydraulic and pneumatic power cylinders. Female rod clevises, female rod eyes, clevis brackets, mounting plates, and pivot pins are described and fully cataloged for easy selection.

No. 364 on Reader Service Card

BEARINGS—A catalog showing their expanded line of miniature precision sintered bearings is available from **Northfield Precision Instrument Corp., Dept. S/A, 4400 Austin Blvd., Island Park, N.Y.** Both flanged and sleeve bearings are listed in bore ranges from 0.025 to 0.3127 in. These bearings are sintered with molybdenum disulphide and vacuum impregnated with instrument oil for lubrication.

No. 365 on Reader Service Card

NETWORK DESIGN — A new work form to assist engineers and purchasing personnel in specifying resistor networks is being distributed by **General Resistance, Inc., Dept. S/A, 430 Southern Blvd., New York 55, N.Y.** Originally designed for internal use at General Resistance, the Network Design Form is designed to save engineering time and provide copies for distribution and reference.

No. 366 on Reader Service Card

CABLE—a new extensible cable is introduced in an illustrated folder from **Spectra-Strip Wire & Cable Corp., Dept. S/A, P.O. Box 415, Garden Grove, Calif.** Engineering charts for the new product are also available.

No. 367 on Reader Service Card

FLEXIBLE HOSES—High-pressure-aircraft and extra-high-pressure-missile flexible hose assemblies are discussed in an eight-page catalog issued by **Resistoflex Corp., Dept. S/A, Roseland, N.J.** Design details are given for Fluoroflex-T hose assemblies rated for service from −67 to 450 deg F, and ranging from 3000 psi heavy duty impulse service to 6000 psi limited surge service. Typical applications include flight controls, braking, ejection gear, gimbal control, and launch equipment.

No. 368 on Reader Service Card

SPRINGS—This 16-page manual summarizes basic information on helical springs, flat springs, wire forms, special fasteners, and assembled spring-like devices. Issued by the **Associated Spring Corp., Dept. S/A, Bristol, Conn.**, it includes design briefs which simplify the specifying of compression, extension, torsion, and flat springs. Case histories illustrate the advantages of early consultation with the springmaker on the design of parts.

No. 369 on Reader Service Card

HYDROFORMING—A complete hydroforming service is offered in an illustrated folder from **C. B. Kaupp & Sons, Dept. S/A, Newark Way, Maplewood, N.J.** Work capacities of the company's 8-in., 12-in., and 19-in. hydroforms are given.

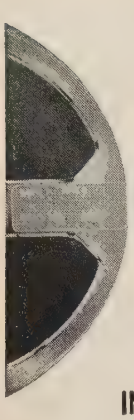
No. 370 on Reader Service Card

ALLOY—A data sheet on STa-900, a 90 tantalum −10 tungsten alloy, is available from **Stauffer Chemical Co., Metals Div., Dept. S/A, 1201 S. 47th St., Richmond 4, Calif.** Illustrated with graphs, it lists the alloy's physical and mechanical properties and discusses its fabrication.

No. 371 on Reader Service Card

COAX TRANSMISSION—A comprehensive description on a line of straight sections, connectors, elbows, and all hardware and accessories necessary for installation is given in a new catalog on rigid coaxial transmission lines prepared by **Technical Appliance Corp., Dept. S/A, Shelburne, N.Y.** Complete with illustrations, it covers both EIA and "Quick-Clamp" connections.

No. 372 on Reader Service Card



WORKING PARTNERS

RCA 501 AND SOUNDCRAFT INSTRUMENTATION TAPES

For many corporations, the heart of their data handling operation will be the new RCA 501 Computer System. Soundcraft Tape proved to be the perfect working partner for the "501" — not only in the crucial testing of the computer, but afterward, in continuous working use.

Experience has proven that Soundcraft works best on leading computer systems, like the RCA 501. Why not let Soundcraft Instrumentation Tapes go to work for you. Complete literature on request.

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R-116

No. 199 on Reader Service Card

DATA PREVIEW

SILICONE COMPOUNDS—A series of new self-bonding silicone rubber compounds is described in Bulletin SE-5504U from **General Electric Co., Silicone Products Dept., Dept. S/A, Waterford, N.Y.** The four-page, illustrated booklet discusses applications for the new materials and includes tables of typical properties.

No. 373 on Reader Service Card

BEARING — All standard miniature bearings in their RMB line are described in a new 16-page catalog just issued by **Landis & Gyr, Inc., Dept. S/A, 45 W. 45 St., New York 36, N.Y.** Designated Catalog 3E, it includes actual size drawings as well as full dimensional data.

No. 374 on Reader Service Card

UNION FITTING—Illustrated Bulletin 804 has been issued by **Marman Div., Aeroquip Corp., Dept. S/A, 11214 Exposition Blvd., Los Angeles 64, Calif.** The bulletin provides specifications on their Conoseal union fitting.

No. 375 on Reader Service Card

TUBING—Heat-shrinkable plastic tubings are described in a two-color folder from **L. Frank Markel & Sons, Dept. S/A, Norristown, Pa.** Properties and dimensions of the Flexite Shrinkdown tubings are listed.

No. 376 on Reader Service Card

TOOL STEEL—An air-hardening tool steel for tools and dies which require extreme shock resistance is described in a technical data sheet issued by **The Carpenter Steel Co., Dept. S/A, Reading, Pa.** The data includes various stress and hardness curves, as well as heat treatment information and mechanical properties.

No. 377 on Reader Service Card

GLASS FABRIC—Bulletin 51.5.20 gives full specifications on a continuous filament woven glass fabric bonded with a flame-retardant epoxy resin which is manufactured by **Taylor Fibre Co., Dept. S/A, Norristown, Pa.** The data include characteristics, forms, punching, and minimum or maximum property values of sheet stock. Both physical and electrical properties are covered.

No. 378 on Reader Service Card

VALUABLE REFERENCE

free 84-PAGE CATALOG

One Complete Source of Detailed Specifications for Designers, Production Managers, Toolroom Foremen

Hundreds of NEW ITEMS

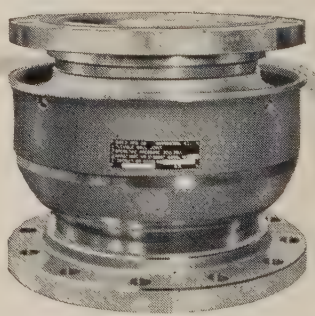
ALL NEW — Complete specifications and cost saving data on over 2000 "Standards", including world's largest line of work-holding equipment, chuck jaw blanks, handles, knobs, wheels, strap clamp assemblies, forged items, plus hundreds of other jig and fixture components. Detailed specifications, engineering drawings. The one complete source for data on all the "standards" for tool, die, jig, and fixture design and application. Write for your FREE copy today.

JERGENS TOOL SPECIALTY CO.

Dept. SA-9 712 East 163rd Street, Cleveland 10, Ohio

No. 200 on Reader Service Card

NEW, lighter weight flexible BALL joints



SIZES: 3", 4", 6", 8", 10", 12"

for CRYOGENIC piping

FOR PROJECT REQUIREMENTS—In handling fluid fuels and oxidizers, including liquid oxygen. Also in industrial cryogenics for liquid methane and liquid propane or butane at low, as well as ambient, temperatures.

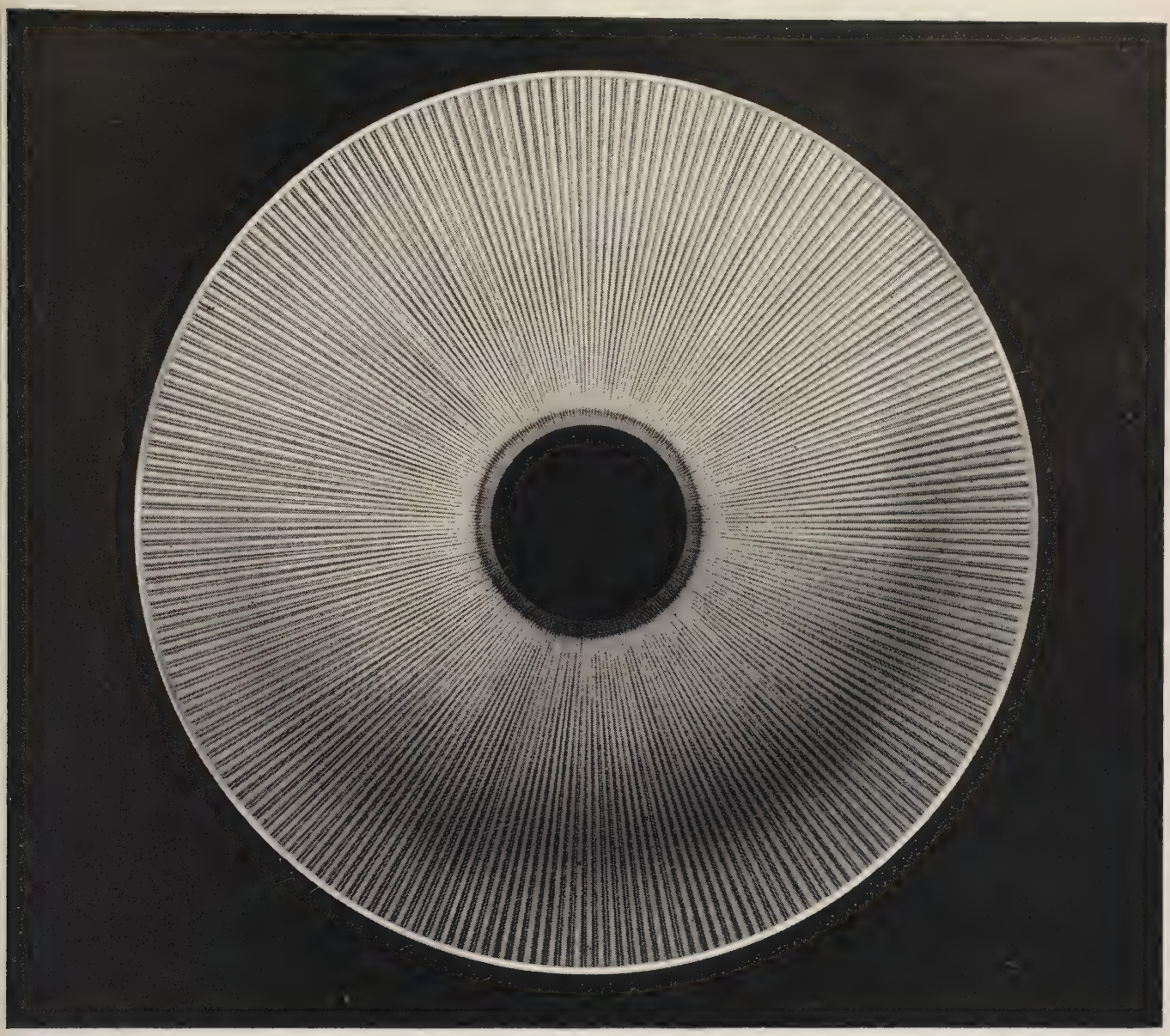
RECOMMENDED SERVICE—(1) Fluid loading arms. (2) Expansion Joints. (3) Gimbal/Rotary Swivel motion. (4) Shock resistant flexible piping.

NEW, ADVANCED DESIGN—Has passed official "Qualification Tests," including shock tests of more than 100G's. TEMPERATURES: −320°F to +275°F. PRESSURE RATING: Designed for and qualification tested at 200 psi operating, 300 psi proof, 700 psi burst pressures. *Ask for Bulletin 233 B.* BARCO MANUFACTURING CO., 575K Hough St., Barrington, Illinois.

1st for SAFETY BARCO

No. 201 on Reader Service Card

Tomorrow's tubing technology—today



Where thrust is a must . . . Superior reverse tapered tubing

By using reverse tapered tubing drawn by Superior to extremely close tolerances on OD, wall, rate of taper, location of minor OD and roundness, rocket engine manufacturers have been able to eliminate a number of severe forming operations, space the tubes with less difficulty, and control to a greater degree the finished tolerances of the thrust chamber. Another important advantage is freedom from ID cracks.

Superior reverse tapered tubing is available in sizes from .080 in. minor OD to 1½ in. major OD with wall thicknesses from .012 to .0625 in. However, the difference between major and minor OD cannot exceed .280 in. in any single length of tubing. Any analysis that can be readily cold worked from Superior's line of more than 120 standard and special analyses can be supplied. To date, the most interest has been in the 300 and 400 Series stainless steels and the nickel alloys, particularly Inconel X.*

To assure reliability, we can test the tubing nondestructively before tapering by eddy current, ultrasonic, dye penetrant and hydrostatic procedures. Send for complete information about Superior reverse tapered tubing. Superior Tube Company, 2038 Germantown Ave., Norristown, Pa.

*Reg. Tm of International Nickel Co.

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West Coast: Pacific Tube Company, Los Angeles, California

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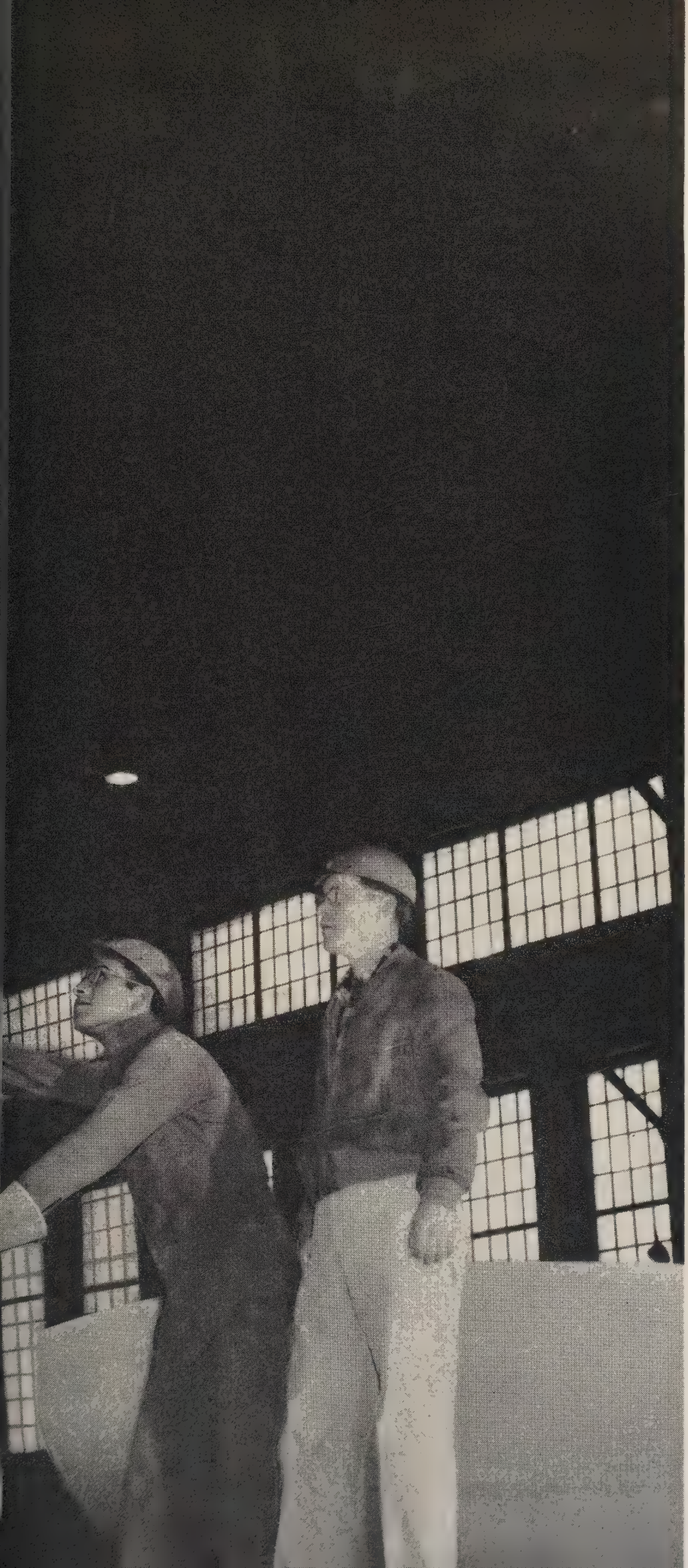
Steel



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LUKENS STEEL

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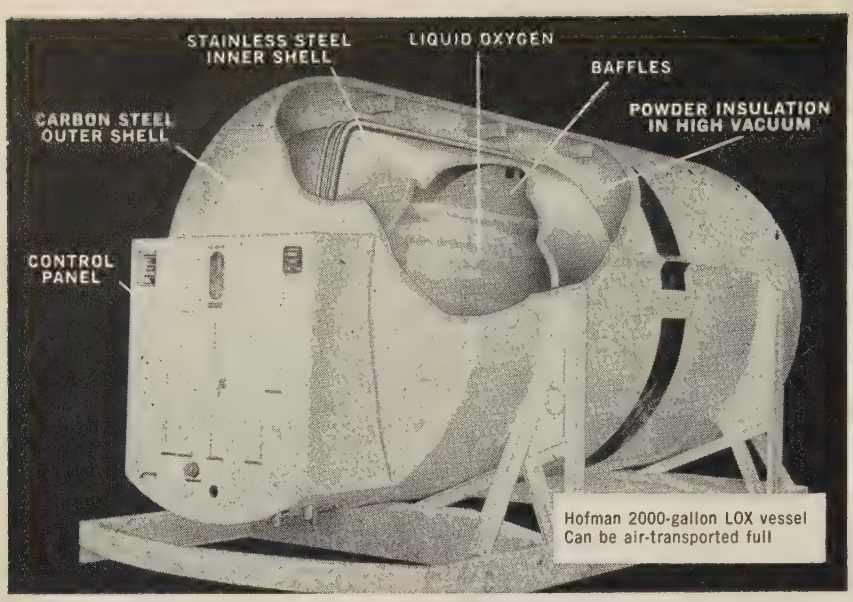

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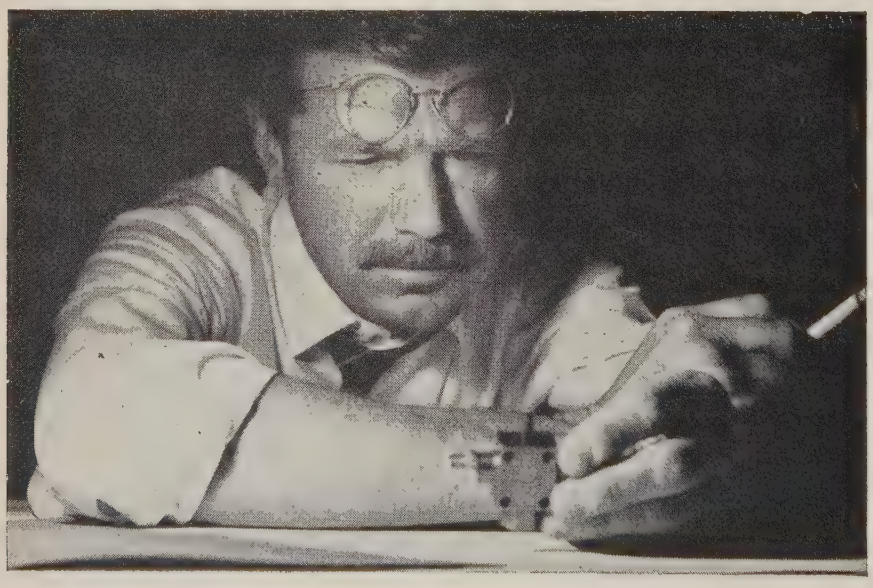

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No. 205 on Reader Service Card

DATA PREVIEW

TUNGSTEN ALLOY—Kennertium W-10, a heavy tungsten alloy, is presented in Bulletin B-500 from **Kennametal, Inc., Dept. S/A, Latrobe, Pa.** The eight-page booklet anounces improved properties for this material and discusses applications in the fields of radioactive shielding, balancing, and high inertia rotation.

No. 379 on Reader Service Card

SELF-ALIGNING NUTS—A two-color folder on SA 16 self-aligning nuts is offered by **Standard Pressed Steel Co., Aircraft/Missile Div., Dept. S/A, Jenkintown, Pa.** It describes how these nuts automatically restore perpendicularity in out-of-squareness conditions as severe as eight degrees.

No. 380 on Reader Service Card

LUBRICANT — Specifications and applications of Dri-Slide are included in a data sheet issued by **Bux Dri-Slide, Dept. S/A, 2950 Hillcroft, S.W., Grand Rapids 8, Mich.** This lubricant is described as molybdenum disulfide dispersed in light petroleum hydrocarbons. Dri-Slide will penetrate MoS_2 into any mechanism, according to the data sheet.

No. 381 on Reader Service Card

BALL VALVES—A bulletin entitled "How to Buy a Ball Valve" is available from **Hydromatic, Inc., Dept. S/A, Bloomfield, N.J.** It shows a cutaway view of a valve, tabulates de-**Slide, Dept. S/A, 2950 Hillcroft,** ploded view and parts list for their Series 701 valve.

No. 382 on Reader Service Card

FASTENERS — A special report for users of high-strength fasteners is offered by **Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa.** The SPS Laboratories Report No. 495 gives 10 recent examples of negligent practises in design and specification, procurement, fabrication, and inspection of fasteners, with recommendations for correction.

No. 383 on Reader Service Card

METAL WEAR PARTS—An illustrated research report from **The Electrolizing Co., Div., Advance Industries, Inc., Dept. S/A, 1505 East End Ave., Chicago Heights, Ill.**, states that the primary cause of erratic performance and premature failure of precisely engineered metal wear parts and bearing surfaces is the presence of microscopic, nonmetallic, abrasive contaminants, mechanically embedded or electrostatically "bonded" to the components. The eight-page technical paper is the result of a two-year investigation undertaken by the company.

No. 384 on Reader Service Card

PLATING — A bulletin on selective plating equipment has been published by **Selectrons, Ltd., Dept. S/A, 520 Fifth Avenue, New York 36, N.Y.** In addition to describing the equipment, this six-page booklet lists more than 24 applications for the process. Typical of these are touch-up of damaged areas without disassembly, resizing of mismachined components, two-tone plating, and deposition of binary and ternary alloys.

No. 385 on Reader Service Card

ABLATION MATERIAL — Tayloron 5000 is the name of a new reinforced plastic which is described in a technical bulletin just issued by **Taylor Fibre Co., Dept. S/A, Norristown, Pa.** The bulletin describes the new material as one which combines ablation resistance with thermal insulation and heat resistance, and which is 25 per cent lighter in weight than presently available materials.

No. 386 on Reader Service Card

BOLT DAMAGE—An eight-page report has been issued by **Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa.** describing effects of metal damage caused by improper grinding of aircraft fasteners. It discusses the nature of various types of damage and the detection of the condition, and shows how proper fabrication techniques resolve the problem.

No. 387 on Reader Service Card

EPOXY RESINS—Data on the high-temperature properties of Oxiron epoxy resins and on the potential of these materials in laminate applications are reported in Technical Bulletin No. 2 from **Food Machinery and Chemical Corp., Epoxy Dept., Dept., Dept. S/A, 161 E. 42nd St., New York, N.Y.** The six-page bulletin includes information on uses of Oxiron in wet lay-up, prepreg, and printed circuitry laminate applications.

No. 388 on Reader Service Card

RUBBER COMPOUNDS—Engineering Bulletin 5041 provides various engineering data on two compounds developed by **Precision Rubber Products Corp., Dept. S/A, 3110 Oakridge Dr., Dayton 17, Ohio,** for use in nuclear systems where there is exposure to gamma radiation. The bulletin gives test data on compounds 1387 and 4387, which have a reported radiation resistance up to $1x10^9$ roentgens.

No. 389 on Reader Service Card

No. 164 on Reader Service Card

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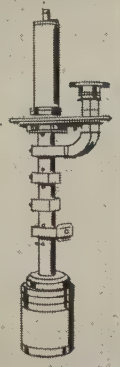
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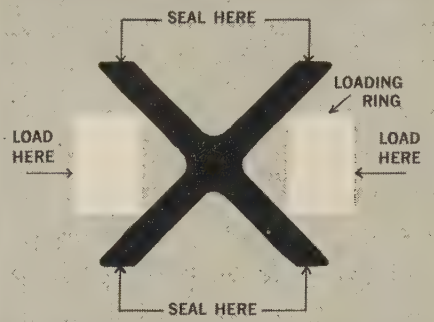

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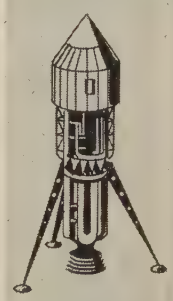
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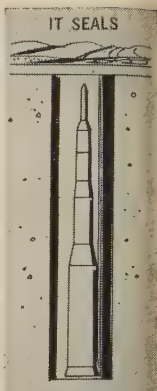
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WELDED DIAPHRAGM BELLOWS
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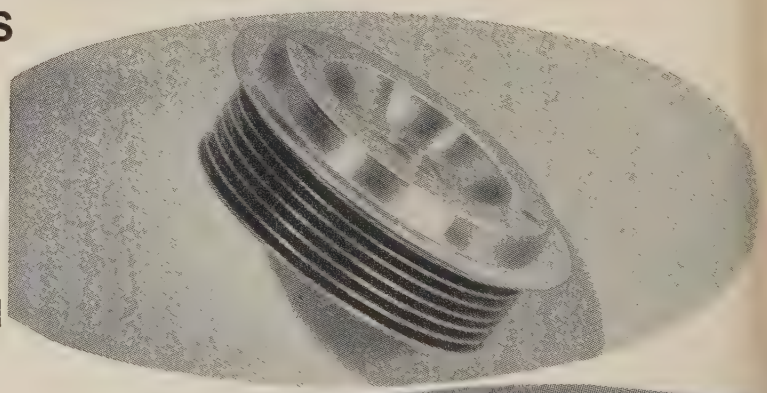
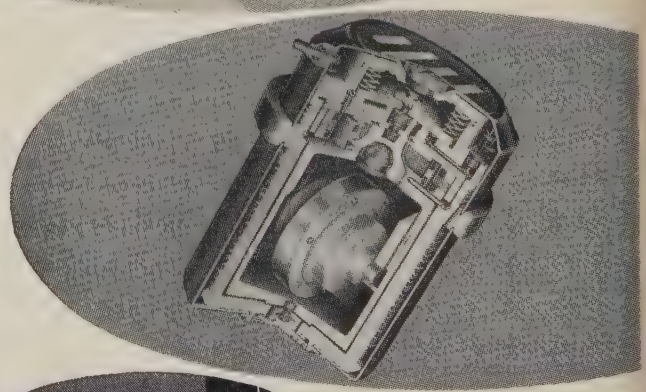
Selected by Minneapolis-Honeywell For New Gas-Bearing Gyroscope





The complex new gas-bearing gyroscope shown here in a cut-away has a bell-shaped ceramic spin motor. Its interior spins at 24,000 revolutions per minute suspended on a film of helium gas only 25 millionths of an inch thick. The gyro weighs just 8 ounces, is 2.8" long and 2.0" in diameter.

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Pacific Division: 20971O Knapp Street, Chatsworth, California

No. 208 on Reader Service Card

ALUMINUM ALLOY — An eight-page bulletin on Precedent 71, a high-strength, shock-resistant, aluminum casting alloy, is offered by **William F. Jobbins, Inc., Dept. S/A, Aurora, Ill.** The two-color booklet describes the new alloy's suitability for various types of castings, and lists its physical properties.

No. 390 on Reader Service Card

II-accessory equipment

EXPLOSIVE VALVES — Four-page Bulletin 1160 XV on the operation, features, and specifications of reusable explosive valves can be obtained from **Conax Corp., Dept. S/A, 2300 Walden Ave., Buffalo 25, N. Y.** The valves, which operate in 0.002 seconds, are used for long and short time storage of gases or liquids up to 5000 psi.

No. 391 on Reader Service Card

AC MOTOR—A data bulletin has been issued by **Hoover Electric Co., Dept. S/A, 2100 S. Stoner Ave., Los Angeles 25, Calif.**, giving information on a Model 1300 208-V, 400-cps, three-phase AC motor. The bulletin gives features of the motor, as well as detailed specifications.

No. 392 on Reader Service Card

ELECTROMECHANICAL DEVICES — A new handbook is now available to assist in the selection and application of electromagnetic clutches and brakes, mechanical clutches, torque indicators, torques standards, and multispeed transmissions. Available from **Autotronics, Inc., Dept. S/A, Florissant, Mo.**, it includes 16 pages of engineering and application information, specifications for 354 standard clutch-brake units, and 60 pages of design specifications.

No. 393 on Reader Service Card

GEARHEADS — A technical handbook and catalog on a line of gearheads and speed reducers is offered by **Superior Instruments & Mfg. Corp., Dept. S/A, 36-07 20th Ave., Long Island City 5, N.Y.** The 28-page book, designated Catalog 600-1, contains a section of engineering data on gearhead design and performance, a catalog section with complete technical specifications and dimensional drawings, a section on Superior packaged servomechanisms, and one on the company's facilities.

No. 394 on Reader Service Card

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No. 211 on Reader Service Card

DATA PREVIEW

FUEL ANALYSIS—A technical bulletin describing a computer service to evaluate rocket fuels and propellants is available from **The Service Bureau Corp., Dept. S/A, 425 Park Ave., New York 22, N.Y.**, an IBM subsidiary. It discusses general specifications of the service, thermodynamic data available, subroutines used to improve the probability of convergence, and the processing schedule.

No. 395 on Reader Service Card

ROLLING DIAPHRAGMS—A design manual covering description, operation, advantages, installation, and design data on friction-free rolling diaphragms is offered by **Bellofram Corp., Dept. S/A, Blanchard Rd., Burlington, Mass.** It also includes a nomograph for fast figuring of maximum up or down strokes in piston applications of these diaphragms.

No. 396 on Reader Service Card

POTENTIOMETERS—A revised bulletin has been prepared by **Voak Engineering Co., Dept. S/A, 129 A Street, Upland, Calif.**, describing three-, five-, and 10-turn potentiometers. These Milipots feature end resistance as low as 0.015 per cent of total resistance, elimination of C rings, and all-metal end covers. Resistance range is from 25 to 200K ohms; best linearity tolerance is ±0.1 per cent.

No. 397 on Reader Service Card

SERVOMOTOR—A data sheet describing a size servomotor has been published by **Helipot Div., Beckman Instruments, Inc., Dept. S/A, 2500 Fullerton Rd., Fullerton, Calif.** It provides photographs, outline and schematic drawings and the torque-speed curve, electrical and mechanical specifications, dynamics, and construction features.

No. 398 on Reader Service Card

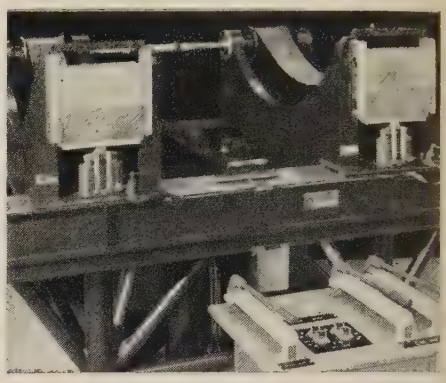
SEALED VALVES—Hermetically sealed valves for service in pressurized water reactors, and containment of toxic radioactive or corrosive liquids and gases are the subject of an 8-page brochure issued by the **Atomic Power Dept., United Shoe Machinery Corp. Dept. S/A, Beverly, Mass.** It provides photographs, drawings, and operating and performancec data.

No. 399 on Reader Service Card

SWITCHES—A 48-page catalog describing its line of switches has been published by **Daven Co., Dept. S/A, Livingston, N. J.** It discusses applications, materials and characteristics.

No. 400 on Reader Service Card

INSTRUMENTATION FOR AEROSPACE



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See pages 174, 175

No. 213 on Reader Service Card

SYNCHRO — A 27-page illustrated technical manual covering the electrical characteristics of synchros and resolvers is available from **Theta Instrument Corp., Dept. S/A, 520 Victor St., Saddle Brook, N. J.** It provides details on the application and significance of such parameters as electrical error, electrical zero, fundamental null, total null, transformation ratio, and phase shift.

No. 401 on Reader Service Card

LOX-CLEANING — A brochure from **Stellardyne Laboratories, Inc., Dept. S/A, 7739 Cuyamaca St., Gillespie Field, El Cajon, Calif.,** describes permanent and mobile facilities for lox-cleaning and packaging of fluid systems and components. It is illustrated with photographs.

No. 402 on Reader Service Card

MINIATURE BEARINGS — This 40-page catalog on miniature and instrument precision ball bearings is being offered by **The Fafnir Bearing Co., Dept. S/A, 37 Booth St., New Britain, Conn.** The catalog contains actual size photographs of the bearings, design application data, and specifications.

No. 403 on Reader Service Card

CRYOGENIC PUMP—A data sheet on the Model CL-1 high-pressure cryogenic pump is available from **The Cosmodyne Corp., Dept. S/A, 12833 Simms Ave., Hawthorne, Calif.** Illustrated with a graph and diagrams, it gives the pump's design features and specifications.

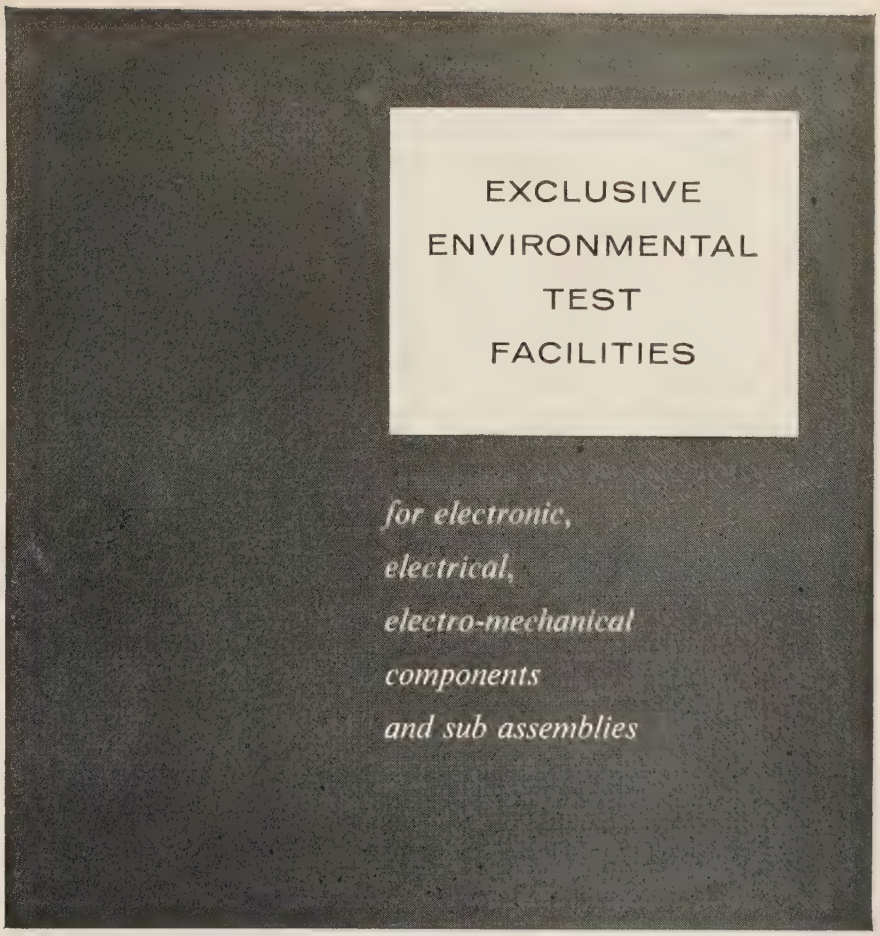
No. 404 on Reader Service Card

HEATERS — Space heaters for mobile and portable military shelters are offered in a two-color folder from **Hunter Mfg. Co., Dept. S/A, 30525 Aurora Rd., Solon, Ohio.** Hunter systems for engine heating, torch heating, and refrigeration are also briefly described.

No. 405 on Reader Service Card

IMPULSE BOMB—Bulletins 60601 and 61602 have been prepared by **Technoproducts, Inc., Dept. S/A, Hamden 18, Conn.,** on their Model 601 impulse bomb. The former bulletin is a data sheet; the latter operating instructions and parts list. Other literature issued by the company is a reprint of a paper entitled "A Ballistic Bomb Method for Determining the Experimental Performance of Rocket Propellants."

No. 406 on Reader Service Card



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No. 215 on Reader Service Card

COMPRESSOR SYSTEMS—Bulletin 189 from **Clark Bros. Co. Div., Dresser Industries, Inc., Dept. S/A, Olean, N.Y.**, presents high pressure packaged compressor systems. Design features of several models are described and illustrated.

No. 407 on Reader Service Card

Ill-testing & support equipment

FUEL FLOWMETER—A mass fuel flowmeter designed to meet highly accurate measurement requirements is covered in Bulletin GEZ-3089, issued by **General Electric Co., Dept. S/A, Schenectady 5, N.Y.** Application features, principles of operation, and schematics are included for this Model TJ-62 fuel flowmeter.

No. 408 on Reader Service Card

TEST EQUIPMENT—This eight-page handbook describes and illustrates the use of semiconductor test equipment in the development of solid state circuitry. Available from **Owen Laboratories, Inc., Dept. S/A, 55 Beacon Place, Pasadena, Calif.**, it provides details on six cost-saving applications of semiconductor analyzers.

No. 409 on Reader Service Card

TRANSDUCERS—A new series of differential transformer and variable reluctance pressure transducers are described in information available from **Gulton Industries, Inc., Dept. S/A, 212 Durham Ave., Metuchen, N.J.** Both units are reported available with either of two diaphragms for each of seven pressure ranges from 0-15 to 0-500 psig.

No. 410 on Reader Service Card

MEASURING INSTRUMENTS—A two-color brochure from **The Meriam Instrument Co., Dept. S/A, 10925 Madison Ave., Cleveland 2, Ohio**, briefly describes the company's facilities for design and manufacture of precision control, monitoring and testing systems. Illustrated with photographs, it also presents typical products.

No. 411 on Reader Service Card

TORQUE MEASUREMENT—A 12-page brochure from **Power Instruments, Inc., Dept. S/A, 7352 N. Lawndale Ave., Skokie, Ill.**, illustrates how to measure the torque characteristics and speed of motors, gear trains, servo mechanisms, and potentiometers. It covers torque ranges from ¼ gm-cm to 200 lb-in.

No. 412 on Reader Service Card

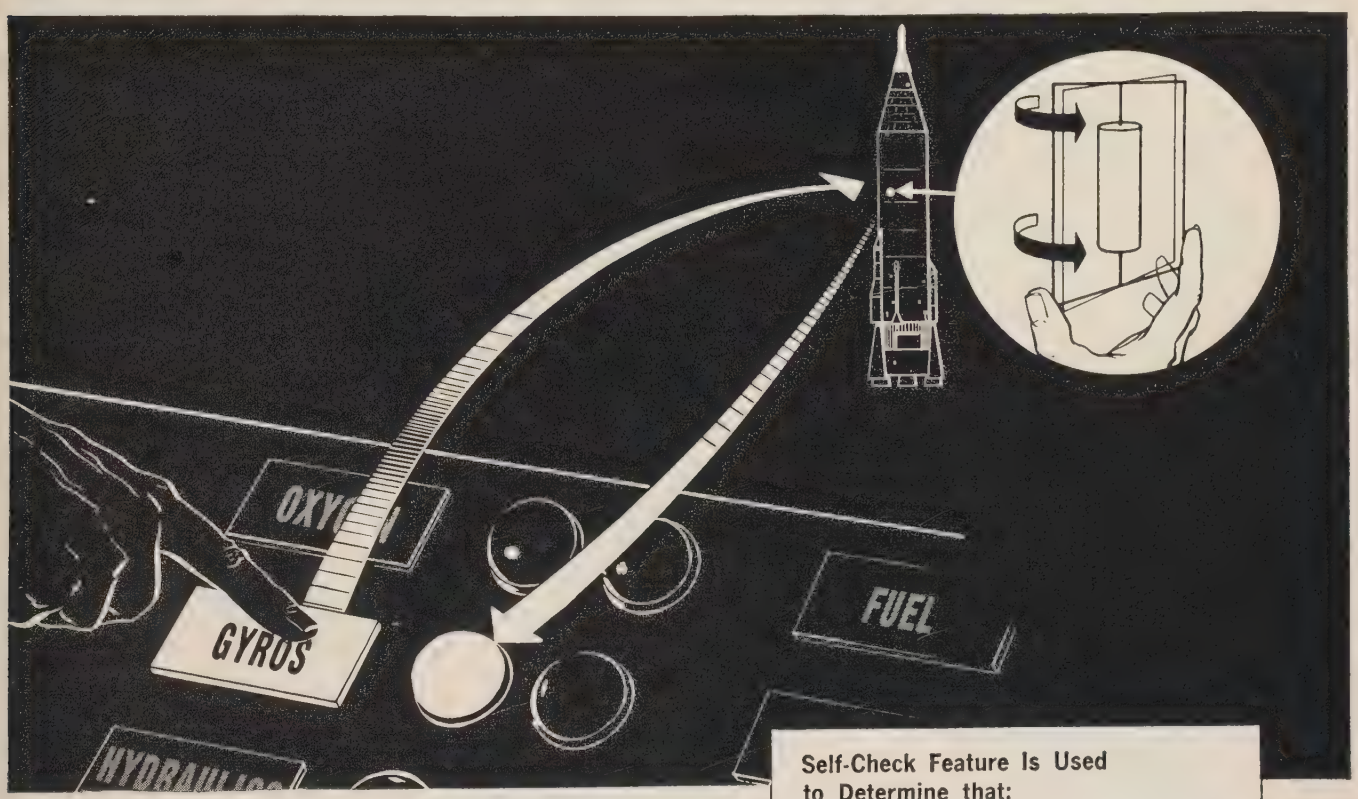
"NEW TWIST" ADDED TO SELF-CHECK RATE OF TURN GYRO

In the new Rate of Turn Gyroscope, Model JRS Series, self-check determinations go beyond the usual wheel speed performance test. Now a gimbal operation check has been added.

When a signal is initiated from the control panel, a torquer within the gyro twists the gimbal. The resulting pickoff signal, identical to that caused by an actual rate of turn, verifies the gyro's state of readiness. With this exclusive feature added to the self-check tests, the Model JRS provides a more complete performance report than conventional self-check gyros. Manual "press-to-test" can be eliminated by programming an automatic integrity check into the countdown sequence.

This new Honeywell Rate of Turn Gyro is a proven reliable instrument designed expressly for flight control and instrumentation in missiles and aircraft where severe ambient conditions prevail. Viscous damping is temperature compensated to maintain virtually constant damping ratio over the entire operating range of $-65°F$ to $+160°F$.

Honeywell inertial components and engineering experience are available to assist in the solution of your gyro problems. Write for Bulletin JRS to Minneapolis-Honeywell, Boston Division, Dept. 14, 1400 Soldiers Field Road, Boston 35, Mass., or call your local Military Products Group Office. Sales and Service offices in all principal cities of the world.



Self-Check Feature Is Used to Determine that:

(a) Gimbal is free to rotate
(b) Restraining Spring is able to return gimbal to zero position
(c) Pickoff generates proper signal, proportionate to gimbal deflection
(d) Gimbal Deflection is proportionate to given torque exerted upon it
(e) Gyro Wheel rotates at proper speed
(f) Damping Ratio of gyro is within acceptable limits

Honeywell Rate Gyro, Model JRS Series. Shown approx. ½ size

PERFORMANCE DATA

- **EXCELLENT LINEARITY:** As low as 0.25% of full scale
- **LOW HYSTERESIS:** Less than 0.1% of full scale
- **LOW THRESHOLD:** Less than 0.01 deg/sec
- **MICROSYN PICKOFF:** Variable reluctance type providing infinite resolution and high signal-to-noise ratio
- **FULL SCALE RATE:** As low as 10 deg/sec
- **FULL SCALE OUTPUT:** Up to 15 volts
- **RUGGED:** Withstands 100 G shock
- **VIBRATION:** Operates at 12 G to 2,000 cps
- **SIZE:** 2.11″ diam. x 4.60″ long
- **WEIGHT:** 2.2 lbs.

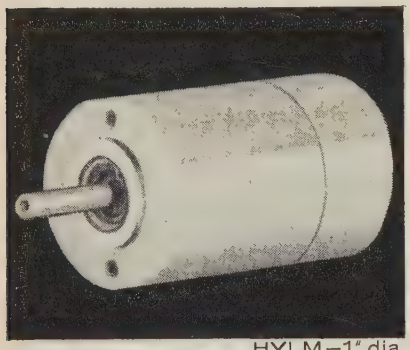
Consult Honeywell for your specific gyro requirements

Honeywell

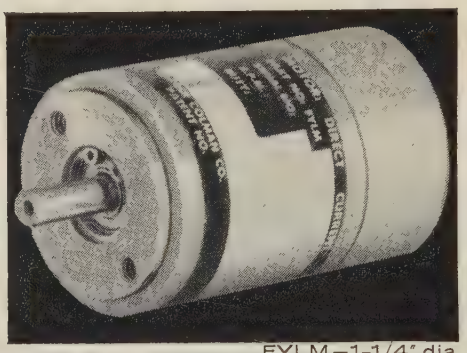
H Military Products Group

No. 216 on Reader Service Card

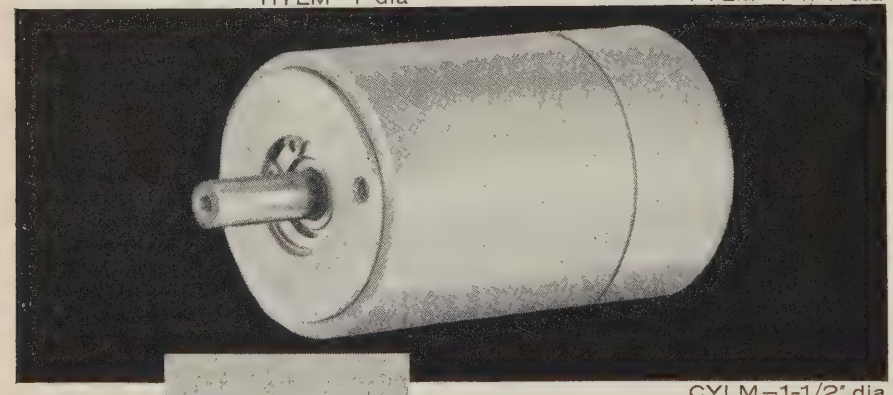
Choose the exact motor you need from the Barber-Colman family of enclosed, permanent magnet, reversible types for industrial and airborne applications



HYLM—1" dia



FYLM—1-1/4" dia



CYLM—1-1/2" dia

THE MARK OF QUALITY

BARBER COLMAN

d-c small motors

TYPE HYLM, top left, typical specifications (27 V): Horsepower, intermittent duty — .017. Torque — 1.0 oz-in. Speed — 17,000 rpm. Power input — 23 watts. Length — 1.59". Diameter — 1.00".

TYPE FYLM, top right, typical specifications: Horsepower, intermittent duty — up to .055. Speed — 5,000 to 20,000 rpm. Power input — 2 to 70 watts. Length — 1.77" to 2.40". Diameter — 1.25".

TYPE CYLM, lower photo, typical specifications: Horsepower, intermittent duty, up to 0.1. Speed — 5,000 to 20,000 rpm. Power input — 7 to 155 watts. Length — 2.125" to 3.125". Diameter — 1.50".

Radio noise filters, gearheads, governors, blowers, other special features also available on above motors.

TOTALLY CLOSED ALL-METAL HOUSING FOR EXTRA STRENGTH AND COMPACT, CLEAN DESIGN

IMPROVED CONSTANT TENSION BRUSH RIGGINGS

ALNICO VI RING MAGNETS CAST IN PLACE FOR MAXIMUM MAGNET AND PHYSICAL STRENGTH

STRAIGHT-THROUGH SHAFTS

MEET MILITARY SPECIFICATIONS

WRITE FOR LATEST QUICK REFERENCE FILE on the complete line of Barber-Colman d-c and a-c motors, tach generators, blowers, gearheads, ultra-sensitive relays.

BARBER-COLMAN COMPANY

Dept. U, 1823 Rock Street, Rockford, Illinois

DATA PREVIEW

TEST EQUIPMENT—The Model TC-109-02 servo temperature conditioning unit is described in a data sheet from **Wyle Manufacturing Corp., Dept. S/A, El Segundo, Calif.** The portable air recirculation unit is diagramed, and its specifications are listed.

No. 413 on Reader Service Card

ASTRONAUTICS — An astronautic chart offered by **Sylvania Electronic Systems Div., Sylvania Electric Products, Inc., Dept. S/A, 63 Second Ave., Waltham 54, Mass.,** is designed to show at a glance the interrelations among distances, orbital periods, and masses throughout the solar system. It is a nomograph, so arranged that a single oblique line gives the characteristics of a particular orbit.

No. 414 on Reader Service Card

CRYOGENIC PROBES—Technical Bulletin 2000 provides operating principles and specification data on a line of cryogenic probes, manufactured by **Trans-Sonics, Inc., Dept. S/A, Burlington, Mass.** Information is also included on trimming networks which are incorporated in some models. Dimension drawings of the various models are also given.

No. 415 on Reader Service Card

BORON DETECTION — Instruments available for the detection of boron hydride are covered in Safety Bulletin CS-001, published by **Callery Chemical Co., Dept. S/A, Callery, Pa.** Included are data on the M-S-A portable borane detector, M-S-A boron analyzer, and M-S-A continuous borane analyzer. The booklet also includes a detailed listing of physical properties of Callery products.

No. 416 on Reader Service Card

FLOWMETERS—A new edition of the Flow Meter Handbook published by **Brown Instruments Div., Minneapolis-Honeywell Regulator Co., Dept. S/A, Wayne & Windrim Aves., Philadelphia 44, Pa.,** is now available. The 170-page book includes schematics, graphs, charts, and tables, and has separate chapters on steam, liquid, and gas flow calculations.

No. 417 on Reader Service Card

STRAIN GAGE — A weldable strain gage capable of continuous operation at 750 deg F is described in Bulletin SG-1. According to **Microdot, Inc., Dept. S/A, 220 Pasadena Ave., So. Pasadena, Calif.,** the gage has been applied to atomic reactors, submarine hulls, the inside walls of chemical vats, and underwater pilings.

No. 418 on Reader Service Card

No. 217 on Reader Service Card

NOISE GENERATORS — A four-page color bulletin on the Stentor series of wide band noise generators is available from **Tenney Engineering, Inc., Acoustics Div., Dept. S/A, 1090 Springfield Rd., Union, N.J.** It includes specifications of the Stentor 203, 204, and 205 noise generators, which are designed for acoustical qualification tests, sonic fatigue tests, transmission loss studies, and material evaluation.

No. 419 on Reader Service Card

TESTING MACHINES—Their complete line of two-screw and four-screw electromatic universal testing machines is described in a 36-page bulletin now available from **Tinius Olsen Testing Machine Co., Dept. S/A, Easton Road, Willow Grove, Pa.** Details and specifications are given on standard split cabinet electromechanical units in capacities to 1,000,000 lb. Data are also included on recorders, related instrumentation, and accessories.

No. 420 on Reader Service Card

The first American Astronaut in Space will rely on a continuous supply of oxygen metered through intricate valving which has been designed by Garrett Corporation, AiResearch Manufacturing Division, engineers with the technical assistance of Stillman Rubber Company experts.

To produce a reliable poppet in sub-miniature size which would meet micro-precision requirements, Stillman Laboratories developed a special compound designed especially for NASA's Project Mercury. This compound, TH-1080, was bonded under critical conditions to the stainless steel body and shaft, and the poppet then ground to precision tolerances.

By close coordination with Garrett engineers, Stillman technicians were able to produce this precision part in only four days from the design release date. Stillman's reputation for quality and reliability in the aircraft and missile industry, together with years of technical experience and know-how, enabled them to produce and deliver the all-new, sub-miniature poppet in record time. These same qualities of experience and technical abilities are available to any industry or manufacturer who specifies the very finest of static and dynamic sealing.

For further information, write to:

STILLMAN RUBBER COMPANY

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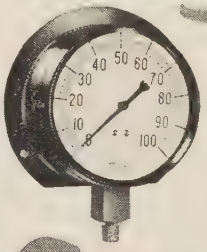

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for the general run of gauge services. Marsh quality and accuracy at a moderate price.

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Within these three comprehensive Marsh groups you have the world's widest (yes, and wisest) selection of pressure gauges. These groups of gauges are not *grades* ... they are *kinds*... the MARSH kind... which means that each gauge, within the scope of its rated use, is the BEST of its kind!

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VALVES

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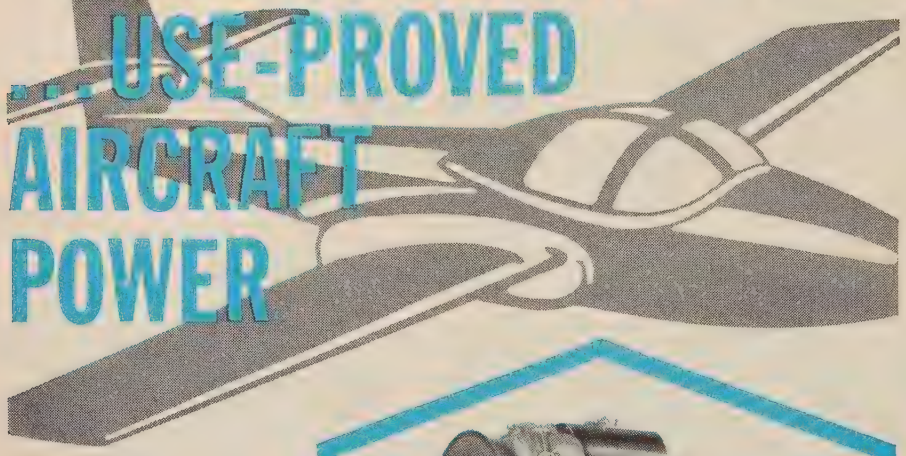
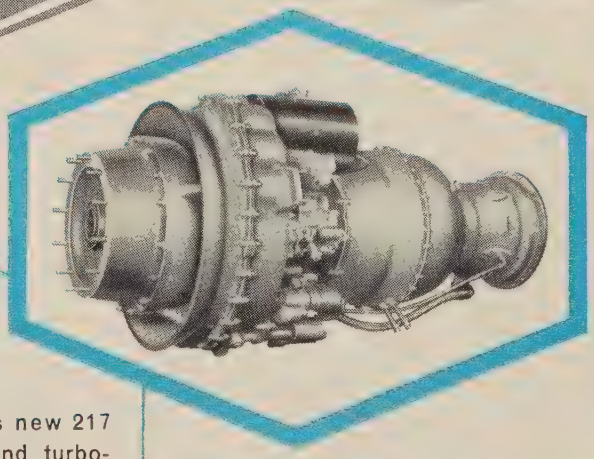
The CONTINENTAL 217 ...USE-PROVED AIRCRAFT POWER





Behind Continental's new 217 series of turboshaft and turboprop engines for business and utility aircraft is a truly impressive record of military service. For the 217 has evolved directly from the highly successful J69, power plant of the Cessna T-37 Trainer and the Q-2C Target Missile, which has withstood 40,000 test stand hours, and more than a million hours in flight.

Model 217-5A has 6000-rpm output shaft, Model 217-6A has 2100-rpm flanged propeller shaft drive. Both versions combine high performance and operating economy with long life, low weight, LOW INSTALLED COST.

PERFORMANCE

500 SHP, with high economy (0.67 SFC).

RELIABILITY

Simple, rugged design . . . Foreign-object-tolerant all-steel rotating system . . . Anti-icing inlet . . . Fail-safe dual element fuel pump . . . Trouble-free fuel distribution system . . . Emergency fuel circuit with manual controls.

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Compactness (19-in. overall diam., 42-in. overall length) . . . Straight-out rear exhaust—no obstructions or turns . . . Front power output on engine center line . . . Front reduction gear surrounded by cool air . . . High accessibility—all accessories mounted around waist . . . Optional mounting: single plane, two-plane, or cantilever . . . Low weight (245 lbs.).

FOR DETAILED INFORMATION, ADDRESS:

CONTINENTAL AVIATION AND ENGINEERING CORPORATION

12700 KERCHEVAL AVENUE, DETROIT 15, MICHIGAN

SUBSIDIARY OF CONTINENTAL MOTORS CORPORATION

WESTERN SALES OFFICE: 18747 SHERMAN WAY, RESEDA, CALIFORNIA

No. 220 on Reader Service Card

MATERIALS TESTING—A condensed catalog of Instron materials-testing instruments is offered by **Instron Engineering Corp., Dept. S/A, 2500 Washington St., Canton, Mass.** Floor and table models are described and illustrated.

No. 421 on Reader Service Card

IV-electronic equipment

DELAY LINES—The Soniline series of sonic delay lines is described in a two-color brochure from **Computer Control Co., Inc., Dept. S/A, Framingham, Mass.** The advantages, parameter ranges, and applications of Sonilines are set forth.

No. 422 on Reader Service Card

HIGH-VOLTAGE COMPONENTS—A new 16-page catalog and applications manual covering a complete line of high voltage components and equipment is available from **Universal Voltronics Corp., Dept. S/A, 17 S. Lexington Ave., White Plains, N.Y.** The catalog also provides information on anti-corona terminations, high-voltage DC supplies, encapsulated power packs, and high voltage meters.

No. 423 on Reader Service Card

TRANSISTORS—"Transistor Guide for Communications Circuit Designers," from **Philco Corp., Lansdale Div., Dept. S/A, Lansdale, Pa.,** summarizes the basic ground rules to be followed in designing transistorized communications circuits. It is illustrated with circuit diagrams, charts, curves, and equations.

No. 424 on Reader Service Card

ANTENNA INSTRUMENTATION—A 16-page, illustrated catalog is now available from **Scientific-Atlanta, Inc., Dept. S/A, Atlanta 9, Ga.** The catalog describes their equipment for antenna pattern recording, receiving, transmitting and control, and antenna positioning, as well as microwave components, auxiliary equipment, and recorder supplies.

No. 425 on Reader Service Card

TRANSFORMERS—Bulletin GEA-7121 describes features and advantages of a line of electronic transformers manufactured by **General Electric Co., Dept. S/A, Schenectady, N.Y.** The illustrated 28-page booklet contains sections on metal-cased, hermetically sealed transformers and inductors, encapsulated, sub-miniature and microminiature transformers. Charts of model numbers, ratings, and dimensions are included.

No. 426 on Reader Service Card

Use the Protection Proved at Over 3,300 mph

Rocket plane X-15 has reached an altitude of over 31 miles at a speed of more than 3,300 mph. ROKIDE Z coating on its engine exhaust area withstands temperatures above 4,000°F.

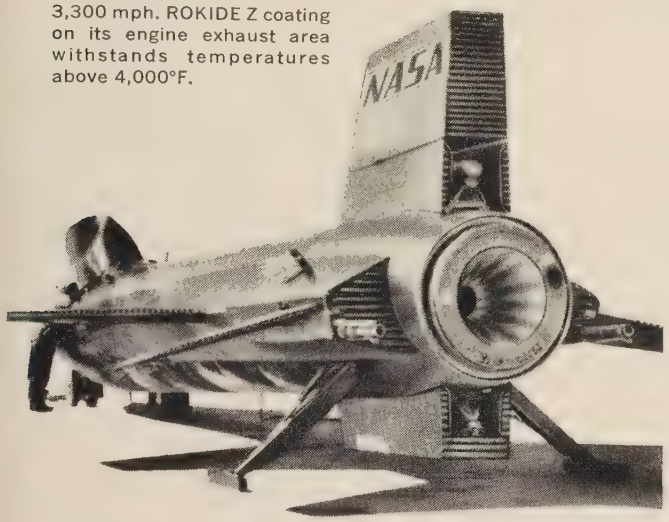

Photo courtesy Reaction Motors Division, Thiokol Chemical Corp.

. . . *ROKIDE* Z coating*

In 80 seconds the 50-foot X-15, USAF-NASA-NAVY research aircraft, rocket propelled and manned, burns up in excess of half its 16-ton starting weight. To protect its XLR99 engine from the tremendous heat generated so quickly and intensely, Norton ROKIDE Z coating is used on the thrust chamber, throat and tail pipe.

What ROKIDE coatings have done for the X-15 and other space craft, they can do for your own developments. Among the large, fast-growing family of Norton refractories, ROKIDE Z zirconium oxide and ROKIDE A aluminum oxide offer maximum protection at minimum weight. In addition, experimental coatings for varying requirements are constantly being developed.

ROKIDE coating facilities are maintained in Norton plants at Worcester, Massachusetts, and Santa Clara, California — and by licensed applicators in key cities. For details, write to NORTON COMPANY, Refractories Division, 648 New Bond Street, Worcester 6, Massachusetts.

*Trade Mark Reg. U. S. Pat. Off. and Foreign Countries.

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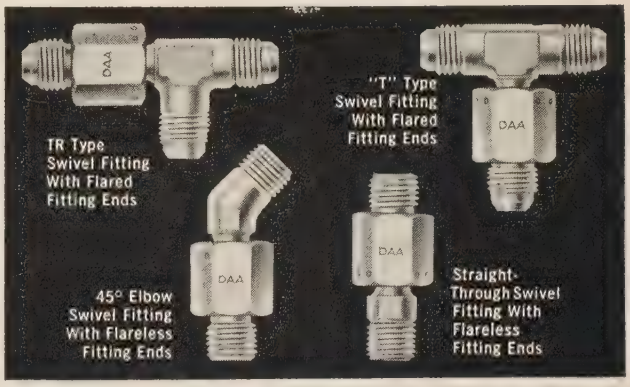
SELF ALIGNING SWIVEL FITTINGS FOR

ANY ANGLE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TR Type Swivel Fitting With Flared Fitting Ends
"T" Type Swivel Fitting With Flared Fitting Ends
45° Elbow Swivel Fitting With Flareless Fitting Ends
Straight-Through Swivel Fitting With Flareless Fitting Ends

Designed by DUMONT ENGINEERING to eliminate stress loads in tubing arising from operation, installation, vibration and other functional characteristics and to maintain a comparatively low torque rating, this small lightweight unit offers an ideal solution for many rotating or oscillating fluid line problems; suitable for operating pressures up to 5,000 PSI.

One of the most outstanding features of this unit is its automatic compensation for misalignment of up to 14° in addition to a 360° rotation. This self-aligning swivel is available with several different configurations to assure its flexibility and usefulness: straight-through, 45° angle, right angle, tee, cross or any angle.

With the characteristics of almost universal application this unit is suitable for nearly all types of liquids and gases. And every unit undergoes rigid inspections for quality control to insure its function and reliability. These units have also been fully tested and qualified per mil Specs bearing the number MIL-J-5513A and MIL-E-005272-B.

Many other designs, sizes and fitting ends are available. For complete information and specifications write or phone:

PATENT APPLIED FOR

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DEPARTMENT S 2, 1401 FREEMAN, LONG BEACH, CALIFORNIA
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A complete run-around cable system provides the finest controls for aircraft. The many features and advantages of a properly designed and true run-around cable system can now be incorporated into component packages. This permits installation and application in many mechanical remote control functions and adds the inherent advantages and reliable performance of precise cable control.

Packaged cable control systems are logical outgrowths of Pacific Scientific Company's extensive experience in the field of mechanical control systems and components. Their flexibility can be used advantageously in both straight runs and circuitous routing. Modular construction permits easy installation to flexible mountings, structural members and pressure bulkheads.

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No. 223 on Reader Service Card

DATA PREVIEW

MISSILE RANGE DATA—A five-page report from **Computer Systems, Inc., Dept. S/A, Culver Rd., Monmouth Junction, N.J.**, describes a typical instrumentation chain for missile ranges, including vehicle tracking, plotting of tracking data, and control of target acquisition equipment. Designated Form 80-350-TC-3, it is illustrated with diagrams.

No. 427 on Reader Service Card

COMPUTING RESOLVERS — A 16-page, illustrated monograph that describes the characteristics of computing resolvers has been issued by **Theta Instrument Corp., Dept. S/A, 520 Victor St., Saddle Brook, N.J.** Such definitive properties as function error and axis error are explained and techniques of measurement are set forth in detail.

No. 428 on Reader Service Card

TRANSFORMERS—An eight-page general information catalog on a new line of Datapulse transformers is offered by **PCA Electronics, Inc., Dept. S/A, 16799 Schoenborn St., Sepulveda, Calif.** It contains a variety of basic technical data.

No. 429 on Reader Service Card

TUBES—A handbook for design engineers with complete descriptions of low-power transmitting tubes, series regulators, rectifiers, and clipper tubes has been published by **Raytheon Co., Industrial Components Div., Dept. S/A, 55 Chapel St., Newton 58, Mass.** The eight-page booklet charts all specifications and diagrams each tube's base and envelope connections. SA-901-30-K

No. 430 on Reader Service Card

ANTENNAS — A reference data card for antenna design and development laboratory engineers is available from **Blaine Electronetics, Inc., Dept. S/A, 14757 Keswick St., Van Nuys, Calif.** Illustrated with graphs and charts of data for recording antenna radiation patterns, it includes nomenclature, fast calculating equations, and size-frequency coverage of illuminating antennas.

No. 431 on Reader Service Card

RELAYS — An environmental test report on miniature and micro-miniature relays is being offered by **Control Dynamics Corp., Dept. S/A, North Hollywood, Calif.** The report is a compilation of test reports generated during the company's quality assurance program. Each week, samples from production are selected for testing in accordance with Mil-R-5757D.

No. 432 on Reader Service Card

New

LIGHTWEIGHT MIRRORS

FOR AIRBORNE OPTICAL SYSTEMS & THOSE REQUIRING LOW INERTIA

Illustrated: Lightweight concave spherical mirror, 16″ dia.; radius of curvature, 11″; thickness, 4″; **Weight, 5 lbs., 4 oz. If of conventional solid fused quartz, it would weigh 41 lbs.!**

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DOMES • WINDOWS • LENSES
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Luxurious yet informal...spectacular figure-8 pool...fine food at the Cafe Carlton Coffee Shop ...ample parking. It all adds up to the ultimate in convenience and comfort for you!

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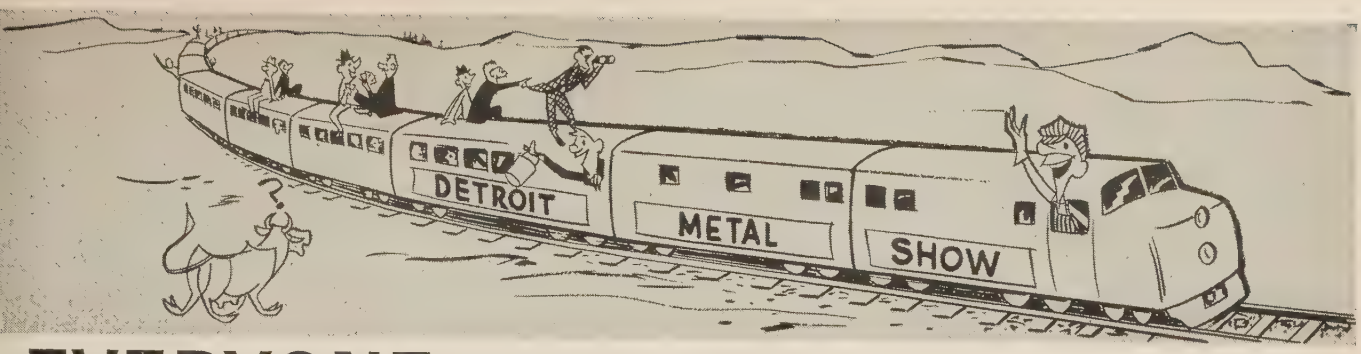
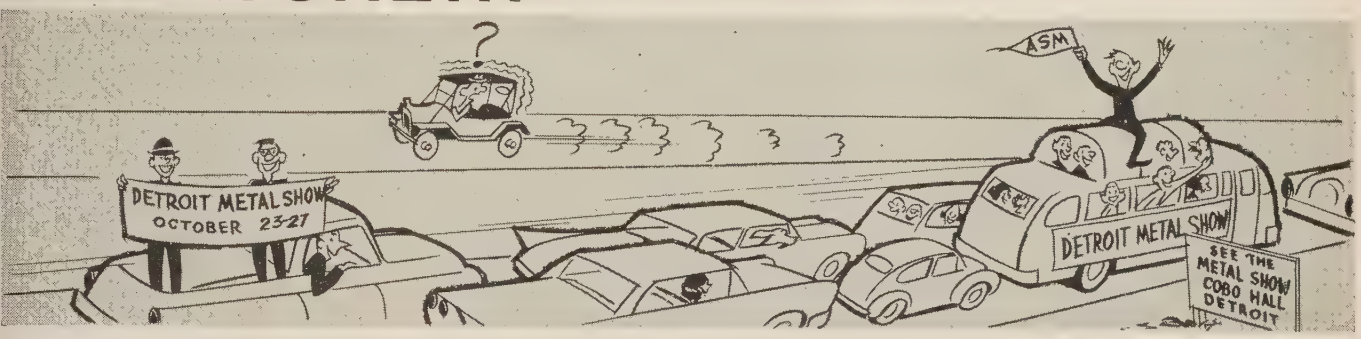
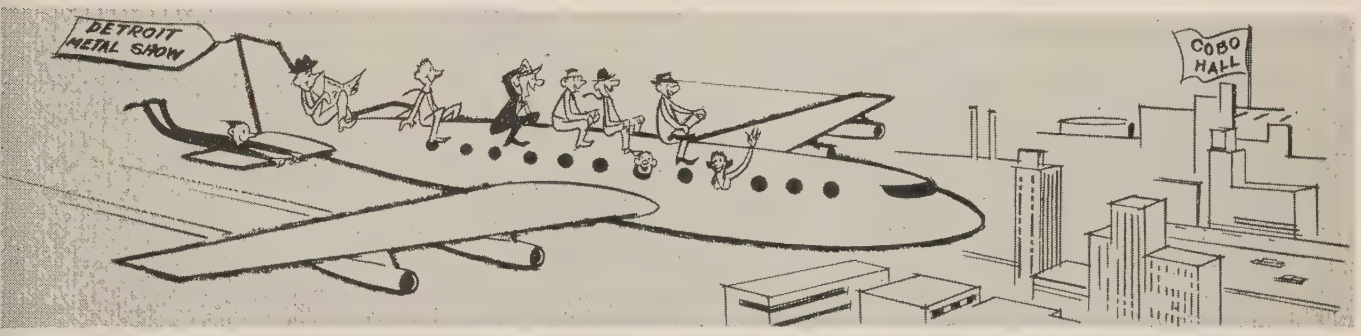


EVERYONE...



10405-ASM

(Well, almost everyone)...



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Gentlemen: Please register myself (and the names of my associates listed below) for the forthcoming METAL SHOW at Cobo Hall in Detroit.

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☐ non-members: $10.00 AIME sessions, ASM sessions and Exposition.
☐ SNT Members: $5.00 Registration fee includes SNT sessions, ASM sessions and Exposition;
☐ non-members $7.00 SNT sessions, ASM sessions and Exposition.

No. 226 on Reader Service Card

THE MARQUARDT TM-1 A FULLY AUTOMATIC TEST MACHINE

The Marquardt TM-1 Autodynamic Elevated Temperature Test Machine is a fully automatic, servo-controlled universal testing machine which measures and records modulus, yield, ultimate strength, and other mechanical properties of materials.

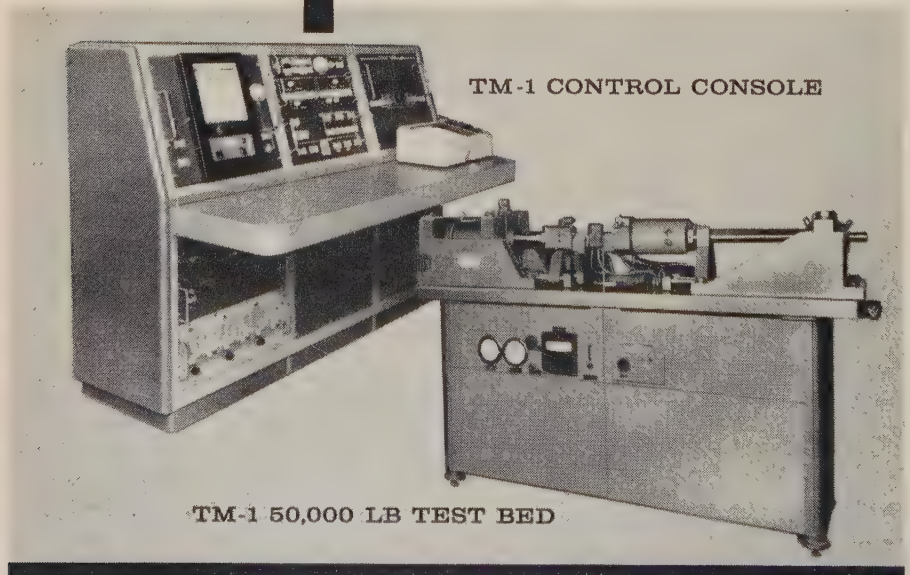
- *The TM-1 automatically* simulates stress and strain conditions to calibrate recorders, eliminating errors and time consuming setup procedures and data reduction.
- *The TM-1 automatically* runs the test per pre-set conditions.
- *The TM-1 automatically* records the test results in the form of a true stress-strain (psi vs. in/in) curve to failure.
- *The TM-1 automatically* reproduces the identical test conditions on additional specimens for reliable comparisons.
- *The TM-1 automatically* heats (and controls the temperature of) the test specimen.

Tests can be run automatically under rapid heating and loading or straining conditions at temperatures from −300°F to +5,000°F; with true gage length strain control from .002 in/in/min to 45 in/in/min for 1 in. gage lengths; from 50 gm. to 50,000 lb. in tension or compression. Load and strain control include uniform rate, cyclic, or complex programs.

Now in production and designed to meet today's most exacting materials testing requirements, the TM-1 is only one of the testing tools in Marquardt's product line which includes other universal testing machines, programmers, power controllers, extensometers, and related equipment.

For details write: Director-Marketing, 16555 Saticoy Street, Van Nuys, California
Sales representatives' inquiries invited.

THE Marquardt CORPORATION
CORPORATE OFFICES, VAN NUYS, CALIFORNIA



TM-1 CONTROL CONSOLE

TM-1 50,000 LB TEST BED

DATA PREVIEW

CONNECTORS—A complete line of RF connectors is presented in a two-color, 120-page catalog from **Kings Electronics Co., Inc., Dept. S/A, 40 Marbledale Rd., Tuckahoe, N.J.** Illustrations and full technical data are given.

No. 433 on Reader Service Card

DISCRIMINATORS — An eight-page brochure describing phase-locked-loop discriminators for telemetry ground installations is available from **Electro-Mechanical Research, Inc., Dept. S/A, Sarasota, Fla.** It features a discussion of the phase-locked-loop characteristics and advantages in FM demonstration and gives specifications of the model 167 (transistorized) and model 165 (vacuum-tube) discriminators. A description of a tape-speed compensation system is also included.

No. 434 on Reader Service Card

COMPONENT ASSEMBLIES—An eight-page booklet from **AMP, Inc., Dept. S/A, Harrisburg, Pa.,** describes a new concept in three-dimensional modular packaging and interconnecting of electronic components. Characteristics and functions of the system, which is called AMP-Meca (*M*aintainable *E*lectronic *C*omponent *A*ssemblies), and the kinds of interconnections it makes possible are discussed, with complementary illustrations.

No. 435 on Reader Service Card

POWER SUPPLIES — A 24-page DC Power Supply Handbook and Catalog is offered by **Dressen-Barnes Electronics Corp., Dept. S/A, 250 N. Vinedo Ave., Pasadena, Calif.** It includes a step-by-step procedure designed for engineers who wish to calculate packaging dimensions for multiple DC outputs.

No. 436 on Reader Service Card

TWTS—Literature on traveling wave tubes is available from **Huggins Laboratories, Inc., Dept. S/A, 999 E. Arques Ave., Sunnyvale, Calif.** Backward and forward wave amplifiers, backward wave oscillators, and special purpose tubes are covered.

No. 437 on Reader Service Card

BRITISH ELECTRONICS — A 28-page booklet, "Annual Review of British Electronic Engineering," has been published by the **Electronic Engineering Assn., Dept. S/A, 11 Green St., London W. 1, England.** Illustrated with photographs, it describes the activities of member firms during 1960 in various branches of electronics.

No. 438 on Reader Service Card

No. 227 on Reader Service Card

HEAT RADIATORS—A 16-page catalog from **The Birtcher Corp., Industrial Div., Dept. S/A, 745 S. Monterey Pass Rd., Monterey Park, Calif.**, describes and gives details and drawings of over 72 transistor/diode heat radiators available from stock. It also includes a variety of information on thermal cooling.

No. 439 on Reader Service Card

RECTIFIERS—More than 150 different silicon diffused rectifiers are described in a new catalog being offered by **Semiconductor Div., Raytheon Co., Dept. S/A, 215 First Ave., Needham, Mass.** Illustrations and complete specifications are given for units ranging from 50 to 600 volts PIV and from 250 ma to 22 amps.

No. 440 on Reader Service Card

SYNCHROS—A quick-reference catalog covering some 200 resolvers and synchros has been prepared by **Instrument Div., American Electronics, Inc., Dept. S/A, 9503 W. Jefferson Blvd., Culver City, Calif.** Ten basic parameters are covered for each unit. Typical views of units, dimension drawings, and circuit diagrams are also included. Units are grouped in terms of size and winding compensation.

No. 441 on Reader Service Card

ACCELEROMETER — A brochure is available from **Donner Scientific Co., Dept. S/A, Concord, Calif.** describing their Model 4310 transistorized linear force balance servo accelerometer. The brochure describes how the unit works, gives definitions and specifications, and provides ordering criteria.

No. 442 on Reader Service Card

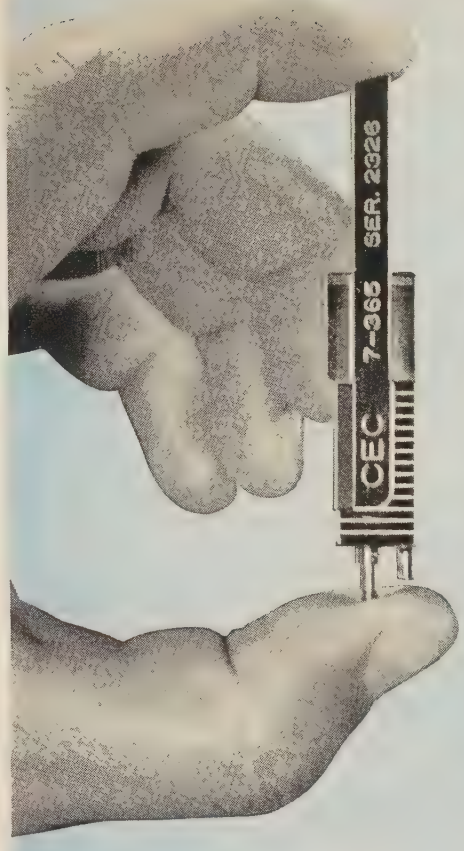
RELAYS—Two specification sheets covering subminiature time delay relays MTRH4 and MTRH8 have been issued by **Branson Corp., Dept. S/A, 41 So. Jefferson Rd., Whippany, N.J.** The operating delay of the MTRH4 is between 1 and 90 sec; the MTRH8 between 15 and 300 sec. Both units will operate in ambient temperatures of —65 to 125 deg C.

No. 443 on Reader Service Card

RE-ENTRY & RECOVERY—A 33-page, illustrated article has been prepared by the **Missile and Space Vehicle Dept. General Electric Co., Dept. S/A, 3198 Chestnut St., Philadelphia 1, Pa.** Covering a complete history of the company's re-entry vehicle development, it provides a cross-section of space programs from the first ICBM and IRBM systems to manned vehicle activities.

No. 444 on Reader Service Card

No. 163 on Reader Service Card



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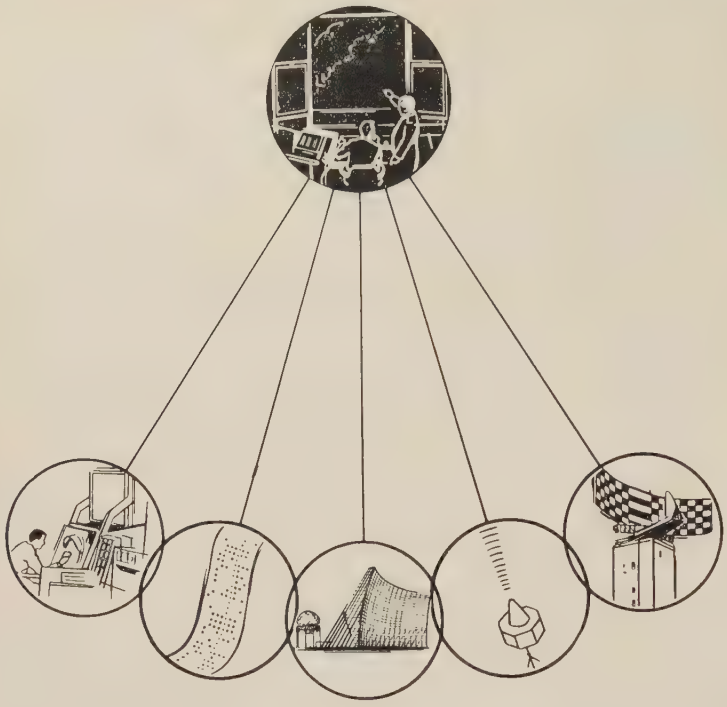

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DATA PREVIEW

POWER SUPPLIES — Transistorized power supplies for military and industrial requirements are offered in a two-color brochure from **Electrodynamic Instrument Corp., Dept. S/A, 1841 Old Spanish Trail, Houston 25, Tex.** Four units are described and illustrated.

No. 445 on Reader Service Card

ELECTRONIC MAINTENANCE — Improvement of maintainability through design is stressed in a Navy electronic equipment design handbook available from the **Office of Technical Services, Business and Defense Services Administration, U.S. Dept. of Commerce, Washington 25, D.C.** It presents estimates of time saving through use of human-engineered construction techniques, and includes checklists of factors to be considered in design, during periodic maintenance, and in maintenance follow-up procedures.

No. 446 on Reader Service Card

SEMICONDUCTORS—The 1961 full-line bulletin from **General Electric Co., Electronic Components Div., Semiconductor Products Dept., Dept. S/A, Electronics Park, Syracuse, N.Y.,** includes all GE transistors, rectifiers, and tunnel diode Jedec types. Transistor and tunnel diode Jedec type numbers are keyed with their outline drawings and cases, and separate listings of military approved rectifier types are given.

No. 447 on Reader Service Card

V-capabilities

FACILITIES—Specialized services for prototype design and manufacture of new machine and other equipment is the subject of a 16-page brochure issued by **Visioneering Co., Dept. S/A, 11830 Brookpark Rd., Cleveland, Ohio.** The publication describes development design services, and manufacturing facilities.

No. 448 on Reader Service Card

CAPABILITIES—A six-page brochure from **The Meriam Instrument Co., Dept. S/A, 10920 Madison ave., Cleveland 9, Ohio,** describes the services of the company's Special Equipment Div. and illustrates its equipment. Designated Brochure SED 100, it discusses the company's facilities and capabilities for development of systems for precision control, operation, monitoring and testing of military and industrial equipment.

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Check Inquiry Form on Page 153

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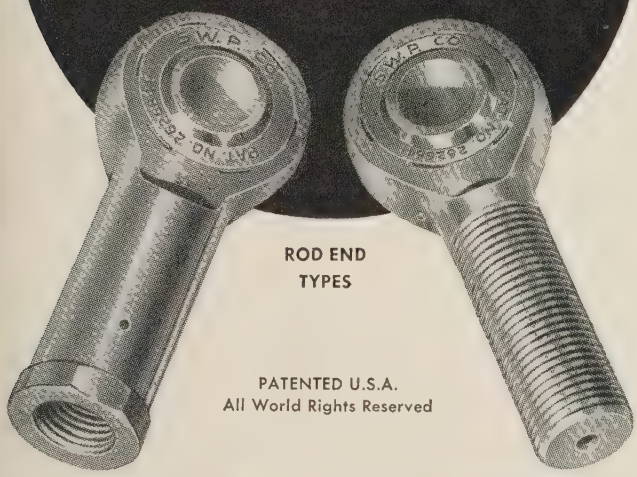

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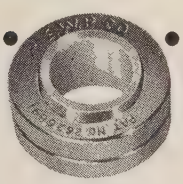

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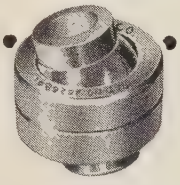

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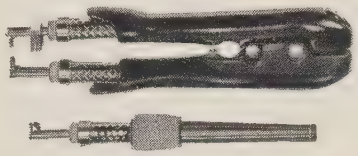

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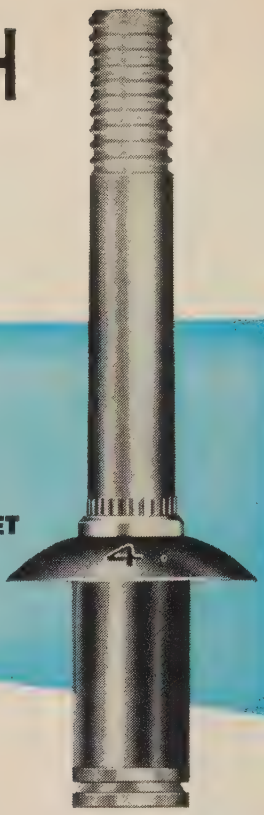

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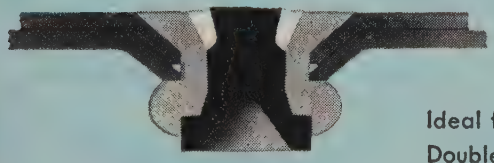

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DATA PREVIEW

FACILITIES—A folder describing its design, testing, and manufacturing facilities has been published by the **Defense Products Div., Brunswick Corp., Dept. S/A, 623 S. Wabash Ave., Chicago 5, Ill.** It discusses missile and aerospace products.

No. 450 on Reader Service Card

STAINLESS STEEL—A booklet entitled "This is Eastern Stainless" describing the facilities, services, and products of this company is available from **Eastern Stainless Steel Corp., Dept. S/A, Baltimore 3, Md.** The booklet contains chemical analysis charts for stainless steel, and a description of each type and finish produced by the company.

No. 451 on Reader Service Card

FACILITIES—Its facilities for engineering, research, and prototype production are described and discussed in an illustrated folder published by **Electrol, Inc., Dept. S/A, Kingston, N. Y.** The folder contains a series of bulletins with details on individual products, such as landing gear, control centers for hydraulic systems, and hydraulic rotary actuators.

No. 452 on Reader Service Card

FACILITIES—The facilities, products and services of **Consolidated Diesel Electric Corp., Dept. S/A, Stamford, Conn.**, are described in a 20-page illustrated brochure available from the company.

No. 453 on Reader Service Card

RESEARCH ACTIVITIES—A discussion of the company's research in the physical sciences is the subject of a 30-page brochure issued by **General Mills, Inc., Dept. S/A, 1620 Central Ave., Minneapolis 13, Minnesota.** Areas covered are; atmospheric and aerosol physics, electron and surface physics, meterology and geophysics, ion and plasma physics, chemistry and materials, electrohydrodynamics, solid state physics, and mechanics.

No. 454 on Reader Service Card

GSE CAPABILITIES—A 26-page booklet entitled "Background of Competence" is available from **United Aircraft Corp., Hamilton Standard Div., Dept. S/A, Windsor Locks, Conn.** It explains the organization, facilities and capabilities of the company's Ground Support Equipment department, with special sections on equipment for air conditioning, fuel handling, ground servicing, and environmental controls.

No. 455 on Reader Service Card

No. 230 on Reader Service Card

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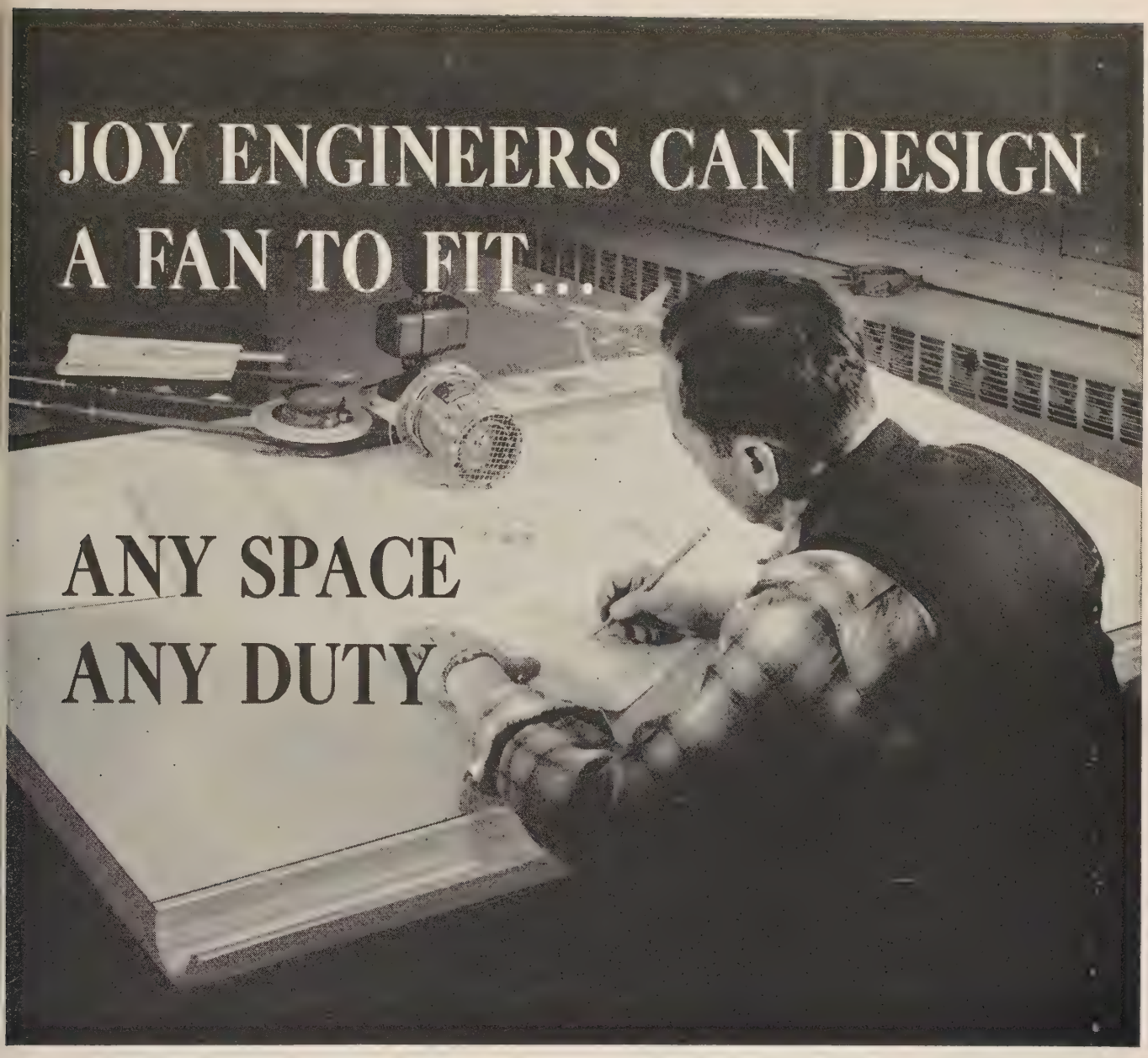

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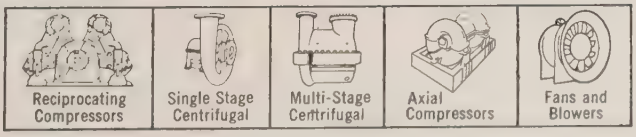

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No. 206 on Reader Service Card

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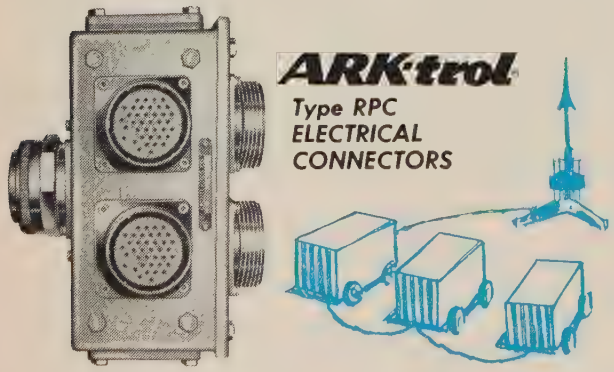

Pictured is RPE Connector with tap box.

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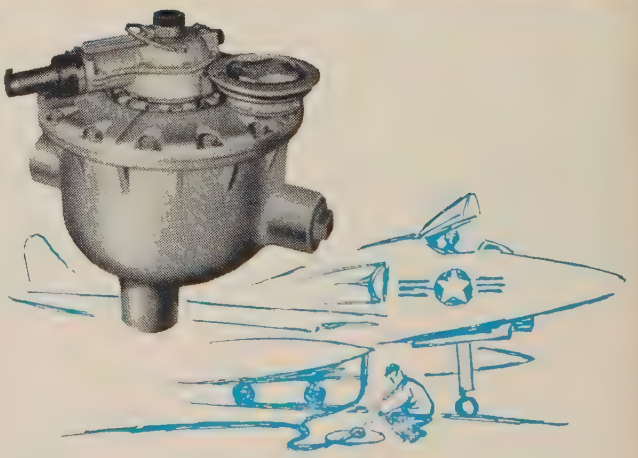

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No. 232 on Reader Service Card

What engineers think about paperwork

THE "average" member of this month's 60-engineer Readers' Round Table spends 4.4 hours a week on non-engineering paperwork and 16.2 hours a week on engineering paperwork. In other words, he has a little less than half his regular working week left for actual engineering.

Typically, he considers the non-engineering paperwork a "necessary bore" that, in the best of all possible worlds, would be done by non-engineering personnel. He enjoys most of his engineering paperwork, but would like more editorial and secretarial help with it.

He obviously knows (although only four respondents come right out and say so) that he's up against a problem. At $5-$8 an hour, he's a bargain, even when he's doing work that a $1.50-an-hour office boy could do as well, since his company can charge his time off as a direct cost on government contracts. He doesn't much like being a bargain.

How Much Is Too Much? Tolerance of time sheets, blueprint orders, and the other diversions that management dreams up to keep engineers away from their

Q. How many hours a week do you spend on non-engineering paperwork (time sheets, vouchers, blueprint request orders, purchasing requests, etc.)?
A. None: 7; Under 5 hours: 33; 5-10 hours: 15; 11-15 hours: 3; Over 15 hours: 2

Q. How many hours a week do you spend on engineering paperwork (work progress reports, formal engineering reports, proposals, etc.)?
A. None: 1; Under 10 hours: 14; 10-15 hours: 16; 16-20 hours: 13; 21-30 hours: 11; Over 30 hours: 5

Non-Engineering Paperwork

Q. How much do you think need not be done at all?
A. None: 25; 25% or less: 1; 26%-50%: 7; 51%-75%: 8; 76%-100%: 12

Q. How much could be done by non-engineering personnel?
A. None: 13; 25% or less: 3; 26%-50%: 5; 51%-75%: 4; 76%-100%: 28

Q. Do you think your immediate supervisor is interested in cutting down your non-engineering paperwork load?
A. Yes: 36; No: 17

Q. Has your company taken any steps that you know of to reduce engineers' non-engineering paperwork load?
A. Yes: 23; No: 36

Engineering Paperwork

Q. By and large, do you enjoy it or dislike it?
A. Enjoy: 28; Dislike: 13; Enjoy some types, dislike others: 5; Neutral —"part of the job": 13

Q. How much, if any do you feel is unnecessary?
A. None: 37; 25% or less: 9; 26%-50%: 7; 51%-75%: 6

Q. Obviously, this type of work can't be done by non-engineering personnel; but could you use editorial help on it?
A. Yes: 39; No: 19

Q. Is any editorial help available to you?
A. Yes: 34; No: 25

Q. Is it adequate?
A. Yes: 16; No: 28

Q. If not, why not?
A. Company's technical writing staff too small: 11; Company's technical writing staff lacks technical qualifications: 13; Help from technical writing staff not assigned: 19; Other reasons: 19

Q. Could you use other types of help (e.g., secretarial) on your engineering paperwork?
A. Yes: 33; No: 25

Q. How many hours per week would the right kind of help on your engineering paperwork save you?
A. None: 24; 25% or less: 9; 26%-50%: 15; 51%-75%: 5; Over 75%: 5

Q. Do you think your immediate supervisor is interested in easing your engineering paperwork load?
A. Yes: 34; No: 24

Q. Has your company taken any steps that you know of to help engineers handle their engineering paperwork?
A. Yes: 17; No: 41

engineering seems to wear thin after the first five hours.

Twenty-three of the 33 engineers who report no more than 1-4 hours a week of non-engineering paperwork think it's all necessary; 20 feel that at least some of it could be done by non-engineers. But only two of the 20 men with non-engineering paperwork loads of more than five hours a week think it all needs to be done, and not one of the 20 thinks that he, as an engineer, should be doing it all.

The men in the low-paperwork group are also more inclined to credit their supervisors and companies with wanting to cut red tape. Twenty-seven of the 33 say they think their supervisors are interested in the paperwork problem. Fifteen think their companies care. Twelve mention specific steps that their companies or departments have taken to reduce their non-engineering routine—hiring of more non-engineering personnel, simplification or elimination of forms.

In the high-paperwork group, only nine of the 20 men think their supervisors want to cut down; even fewer expect them to do so. ("He realizes the problem, but is not putting forth the effort to reduce it . . . " "The more I do, the less he has to do . . . " "As long as the job gets done, who cares?" are typical comments.) Only six of the 20 believe that their companies are trying to reduce the non-engineering paperwork load.

By and large, most respondents are sympathetic or at least tolerant toward their supervisors ("He has too much paperwork himself . . . ").

"Engineers Have Become Errand Boys" When engineers want to let off steam about paperwork, they talk about their companies: "The problem is completely out of my supervisor's control. It must be solved by the company's determining that the engineer is a responsible professional who doesn't need checks at each action he takes . . . " "With the current profit squeeze on aerospace firms, you have to qualify and record your every effort. Engineers have become errand boys for the cost accountant. As a result, creative effort is nil . . . " "Company policy on anything is non-existent . . . " "Company is above average in waste of engineers—almost as bad as the Federal government."

Ten men think all their non-engineering paperwork is unnecesary, 25 think it could be done by non-engineers.

Filling out time sheets is the least popular non-engineering activity. Ordering blueprints (and standing on line for them) is a close second, followed by reading and answering company policy memos that "contain little information." Filing, hunting for library material, and delivering messages and orders in person because the inter-office mail is too slow get several mentions as prime time-wasters.

Engineering paperwork is a different story.

"I Like To Write!" Twenty-eight of the 60 respondents like engineering paperwork, for reasons ranging from "It's a challenge to prepare a good technical document . . . " to "Written record of my work which makes good evidence at raise time . . . " One says simply, "I *like* to write!" Several say that progress reports help clarify their thinking about technical problems.

Most of those who dislike it ("Engineers are educated to design, not shuffle papers . . . ") or just consider it "part of the job" believe that at least 75 per cent of it has to be done.

However, when an engineer thinks that even part of his technical writing time is wasted, he feels strongly about it. "Customer progress reports serve to inform the customer, and are read," says one man. "Few internal progress reports are ever read. Proposals never seem to win on basis of engineering merit, but on political considerations (depressed area, etc.)"

Another, who also likes to write customer progress reports, says that proposals and cost-time estimates "are generally straight——.An honest, well-worked out proposal with pricing data is padded, modified, or combined with junk."

But customer progress reports, too, come in for their share of criticism—half a dozen men think too many are required, especially on government contracts.

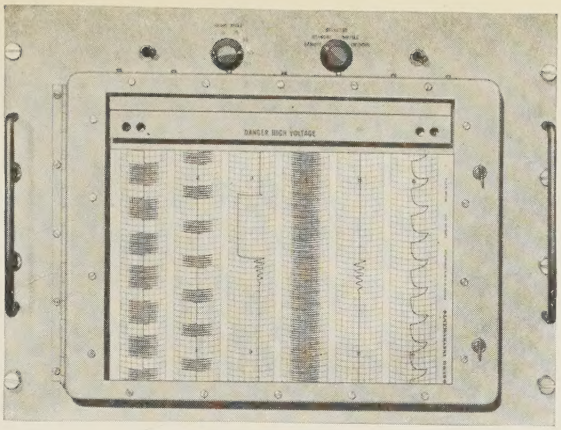
The Trouble with Tech Writers Most engineers say they'd like some editorial help on their engineering paperwork, but only a few think much of their companies' technical writing departments. The most common complaint—checked by 13 engineers and mentioned in comments by seven more—is that tech writers just aren't tech. "Tech staff more concerned with producing a beautiful manuscript than with technical accuracy . . . " and "Not very good at the writing, even on what they do know . . . " are representative remarks. Several engineers say that even when a tech writer is generally well qualified, it's too much trouble to work with him if he's not familiar with the project in hand.

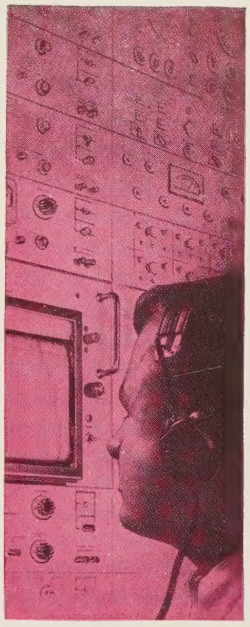
Most of the men who answered "no" when asked if they could use secretarial or other types of non-editorial help on their engineering paperwork went on to explain that they already have enough.

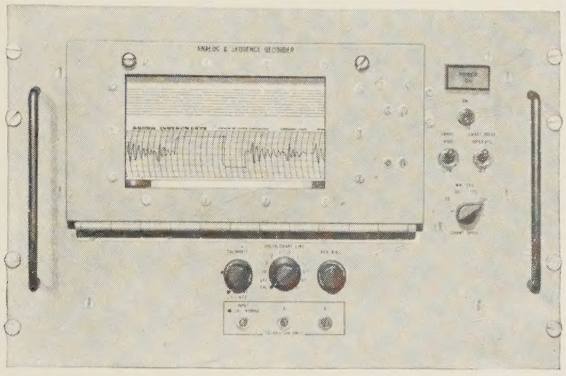
Help Wanted (Female) Of the 33 who say they do need more help, 15 want more and better secretaries, and several mention specifically that one per department won't do. ("There is *one* secretary for 60 engineers in my department . . . " "One secretary for 20 engineers is inadequate, especially if she thinks more of her appearance than her typing.")

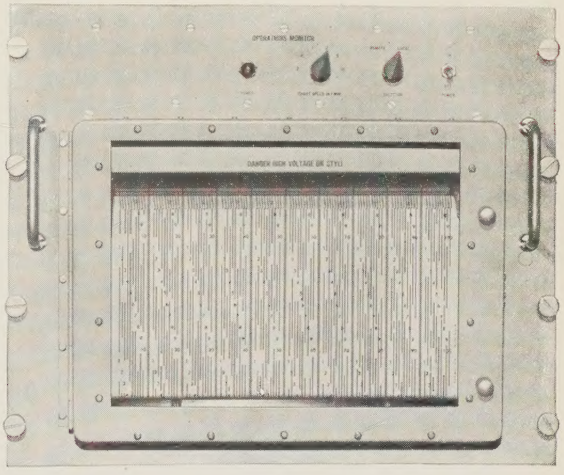
Five engineers would like to try dictating equipment, and half a dozen want technical or semi-technical assistants. Twenty-nine believe that the right kind of help would cut down their engineering paperwork by at least 25 per cent.

This new feature is for (and, to a great extent, by) working engineers. In each issue, it will present the results of a questionnaire survey based on a problem we believe to be of interest and concern to most of our engineering readership. Questionnaires will go to different readers every month. The samples will be small, so the results may or may not be statistically significant, but we hope they'll make good reading. To get the bal. rolling, 60 engineers added a five-page questionnaire on paperwork to their midsummer paperwork load; what they had to say is summarized and quoted on these two pages.









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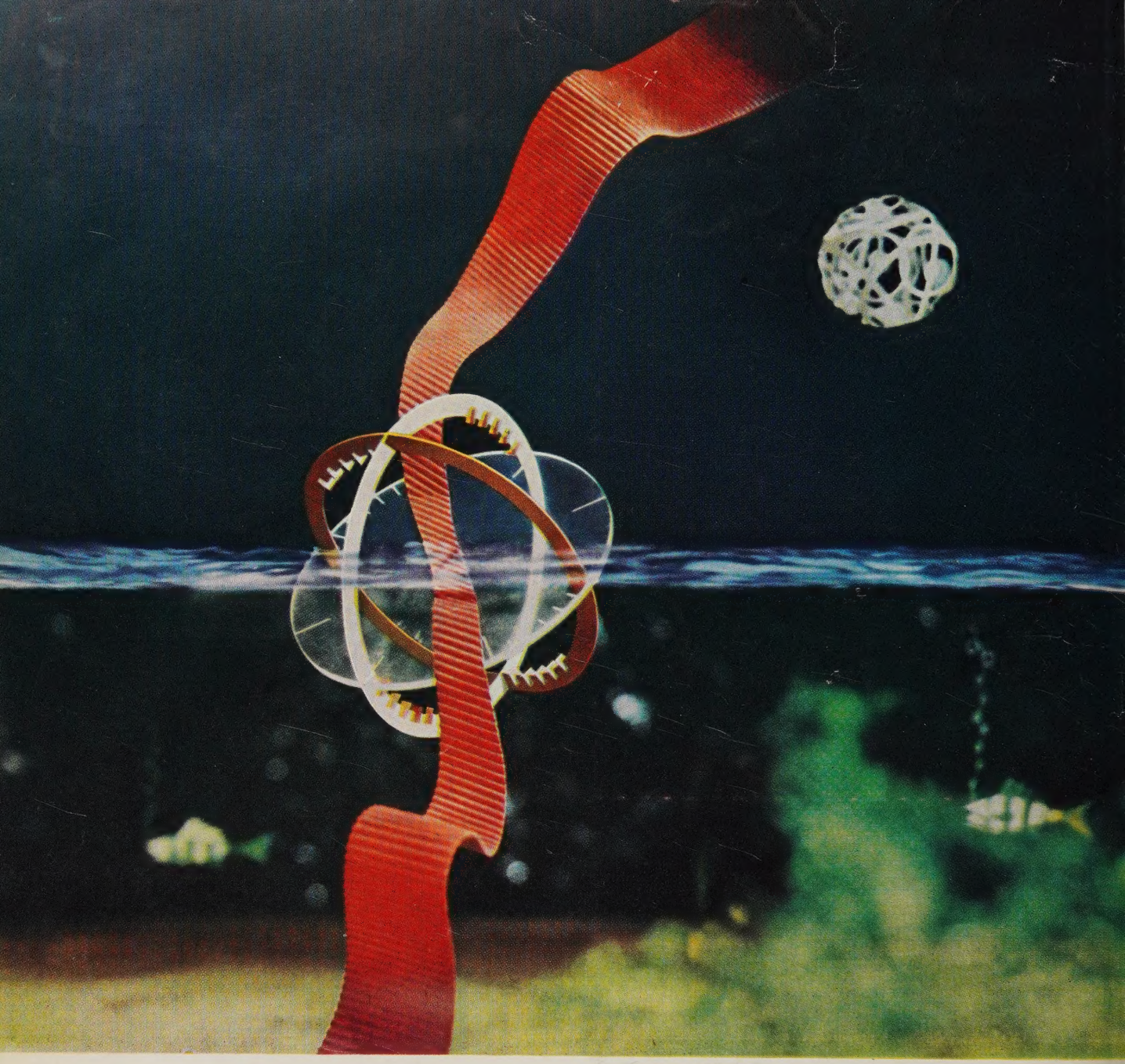

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